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STUDIES IN BONE REGENERATION

AN EXPERIMENTAL STUDY OF BONE TRANSPLANTATION BY MEANS OF A VITAL STAIN

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SINCE the times Ollier and Barth recorded their divergent views on the fate of free bone transplants, numerous investigators have contributed their observations and beliefs as regards this problem, and there has not yet been an agreement on some of the most important questions.

MacEwen believed that bone regenerated only from the cortical bone cells, and that the periosteum had no osteogenetic function and acted as limiting membrane for bone formation. Axhausen expressed the view that bone regenerated from periosteum and endosteum and to some extent from the cortical bone cells, but he emphasized that in the free bone transplant the greater part of the cortical bone degenerated and was absorbed, owing to the fact that it was mechanically impossible for it to obtain adequate nourishment. Nakhara and Dilger, Jakoi, Trinci, Pochhammer, Schepelmann, Mayer and Wehner found that free transplants of periosteum regenerated bone in a certain proportion of instances. Carrel has cultivated periosteum in the thermostat and subsequently transplanted the growing cells and found bone formation. Graves, Gaille and Robertson, Brown and Brown, Albee, and others have found that free transplants of periosteum do not form bone, and they state that periosteum has no osteogenetic properties. Baschirzew and Petrow believe that the periosteum is of value in the clinical use of bone grafts, not for the reason of its having osteogenetic properties, but because it aids in directing and protecting new bone growth. McWilliams believes that the periosteum is important in the clinical use of the bone graft for the reason that it serves to obtain nutrition for the transplant. Lobenhoffer found that, following the transplantation of bone with periosteum, the cortical bone degenerated and was absorbed and that the periosteum remained viable and produced new bone. Murphy, and Brown and Brown believed that the most vital factor in determining the viability and growth of a bone transplant was that the transplant should be placed in contact with living osteogenetic bone. McWilliams found that bone transplants remained viable and regenerated bone when the transplant was entirely separated from bone tissue.

Haas states that regeneration of new bone was never found excepting where periosteum was present. Bier and Haas emphasize the stimulative effect of the presence of blood clot in new bone production. Phemister found that new bone was regenerated from the periosteum and endosteum and to a small extent from the cortical bone cells. He believed the transplanted bone was slowly replaced by the new-formed bone. He emphasized the importance of "functional demand" as a factor in determining the survival and growth of a bone graft.

In a previous publication it was pointed out that sodium alizarine sulphonate had specific vital staining properties for bone tissue. When this dye is given to animals by mouth or subcutaneously it stains only the newly formed bone. This method gives the observer a means of easily determining in gross the amount and site of all new bone formed.

This experimental study of bone regeneration from bone transplants is based on the use of sodium alizarine sulphonate as a vital stain for new bone. The experimental method was the same in all experiments. Dogs were used as the experimental animals. The operations were all done under complete ether anæsthesia. The aseptic precautions were such that infection of the operation wounds did not occur in any instance. A defect in the shaft of the ulna was produced by the excision of 20–40 mm. of the bone with its periosteum. In the earlier experiments, *e.g.*, No. 33, the periosteum was not completely removed along the attachment of the interosseous membrane, between the ulna and the radius, and regeneration of bone was found to take place along the course of the remaining periosteum. Later it was found that the periosteum could be removed entirely if the interosseous membrane was divided before any attempt was made to remove the bone. Numerous experiments have convinced us that the shaft of the ulna in the dog will not regenerate if the periosteum is completely removed along with 4 cm. of the shaft.

The bone transplant or implant was placed in the defect of the ulna. In most experiments the bone transplant or implant was fixed in the medullary canals of the fragments of the resected bone. Living bone transplants were always obtained from the femur. The grafts were cut with a motor saw. Abundant irrigation with salt solution was always used to prevent the saw from becoming hot. In experiments in which the periosteum and endosteum were transplanted with the graft, great care was taken that the periosteum was not detached from the transplant. In those experiments in which the periosteum and endosteum were removed from the transplant they were completely removed along with adjacent layers of cortical bone. The sterile dry bone implants were obtained from old laboratory specimens of bones of dogs which had been sacrificed in other experimental work. The specimens were old formalin preserved specimens which had been dry for several weeks. Silk was used in all experiments as suture and ligature material. The operative wounds were closed with the Halsted epithelial stitch. A plaster-of-Paris dressing was applied to the foreleg of all

dogs operated upon. This dressing was left for variable lengths of time. In all experiments the animals used the operated legs without apparent discomfort. All animals were given subcutaneous or intraperitoneal injections of sodium alizarine sulphonate. In most of the experiments an injection of 3 c.c. of a saturated solution of the dye diluted with sterile water was given intraperitoneally once each week.

The following series of experiments were carried out:

I. Autogenous transplantation of living bone with periosteum and endosteum. Six (6) experiments.

II. Autogenous transplantation of living bone without periosteum and endosteum. Four (4) experiments.

III. Implantation of dried sterile bone. Four (4) experiments.

I. EXPERIMENTS WITH AUTOTRANSPLANTS OF LIVING BONE WITH PERIOSTEUM AND ENDOSTEUM

Experiment No. 26.—Young dog. November 20, 1916. Autotransplantation of living bone with periosteum and endosteum. Seven days.

Ether anæsthesia. Incision in right thigh. Femur exposed. With a motor saw a bone graft 25 mm. long and 2 mm. broad was cut from full thickness of the cortex of the femur. Periosteum and endosteum on graft intact. Wound in thigh closed.

Incision in left foreleg. 25 mm. of ulna removed with periosteum. Bone graft from femur placed in defect. Wound closed.

Two cubic centimetres of a saturated aqueous solution of sodium alizarine sulphonate were given daily subcutaneously.

November 27, 1916, seven days, wounds healed *per primam.* Animal sacrificed. Right femur and bones of the left foreleg placed in formalin.

Macroscopic Examination.—There was very slight pink color under the periosteum of all bones. There were distinct red zones at the epiphyseal lines. The new bone which was forming about the area of excision of the shaft in the femur was stained. The ends of the stumps of the resected ulna were colored. The graft was in good position in the defect. The proximal end of the graft was in contact with the medulla of the proximal stump. The distal end of the graft lay in contact with the periosteum of the distal stump. There was no evidence of new-formed bone along the graft. The specimen was decalcified and microscopical section prepared of the stumps of the ulna and entire length of the graft.

Microscopical Examination.—There was a marked proliferation of cells from the endosteum and periosteum of the stump of the resected bone. Trabeculæ of new bone were being formed. The graft was surrounded by granulation tissue. The lacunæ in the bone graft were for the most part entirely empty. There were small areas scattered throughout the entire length of the graft in which the lacunæ contained cells with normal staining properties. The periosteum and endosteum of the graft for the most part could not be distinguished. There were, however, small areas in which the periosteum and endosteum had remained viable and in which there was definite proliferation of cells of the osteoblast type.

Experiment No. 27.—Adult dog. November 21, 1916. Autotransplantation of living bone with periosteum and endosteum, fourteen days.

Ether anæsthesia. Incision in right thigh. Femur exposed. Bone graft 3

cm. long and 2 mm. thick cut from full thickness of cortex of shaft of femur. Periosteum and endosteum on graft intact. Wound in thigh closed.

Incision in right foreleg. 3 cm. of shaft of ulna with periosteum removed. Bone graft from femur placed in defect. Ends of graft in contact with stumps of resected ulna. Wound closed.

The animal was given on alternate days a subcutaneous injection of 2 c.c. of a saturated aqueous solution of sodium alizarine sulphonate.

December 5, 1916, fourteen days. Animal developed several abscesses in back at sites of subcutaneous injections of the vital stain. Sacrificed. All bones showed a very faint pink color. The femur from which the graft was cut showed the defect filled with callus in which there were areas of ossification. There was also subperiosteal new bone formation about the site of removal of the graft. All new formed bone was stained red.

The ulna which was resected showed a very striking picture. The bone transplant was in perfect position between the stumps of the resected bone. The transplant was not colored. Along the periosteal and endosteal sides of the transplant there were numerous small red dots. With a hand lens these small red areas were clearly small islands of new bone formation (Fig. 1, Plate I). There was also new bone formation at the ends of the stumps of the resected ulna. The distribution of the small islands of growing bone along the entire length of the transplant showed clearly that the bone was growing from the graft. Moreover, the new bone formation was only from the periosteal and endosteal sides of the transplant. Microscopic sections were prepared of the entire length of the transplant and stumps of the resected ulna.

Microscopical Examination.—Sections showed that the lacunæ of the greater portion of the transplanted bone were empty, and these portions of the transplant were obviously not viable. In other areas the lacunæ contained nuclei with normal staining properties. There was no evidence of any particular portion of the transplant remaining viable, but the areas with the lacunæ containing nuclei which stained normally were irregularly distributed throughout the entire graft. Some small spicules of cancellous bone were as obviously completely nonviable as areas in the depths of the dense cortex. There was no evidence of proliferation of any of the cells of the lacunæ. Whether these nuclei with the normal staining properties were bone cells which had remained viable, or whether they were cells which had wandered into the lacunæ from the surrounding tissues could not be determined. This question will be discussed later.

Along the periosteal and endosteal surfaces of the transplant there were areas in which the periosteum and endosteum had remained viable. There was proliferation of cells in these areas with the beginning formation of bone trabeculæ. In other areas there was no evidence of viable periosteum or endosteum. There was no evidence of bone production at any site in which there was not evidence of viable periosteum or endosteum.

There was also growth of new bone from the periosteum and endosteum of the ends of the stumps of the resected ulna. The areas of beginning new bone formation along the graft were certainly independent of the growth of new bone from the stumps of the resected ulna.

Experiment No. 35.—Young dog. December 9, 1916. Autotransplantation of living bone with periosteum and endosteum, twenty-seven days.

Ether anæsthesia. Incision right thigh. Bone graft 35 mm. by 2 mm. cut from full thickness of cortex of femur. Periosteum and endosteum intact. Wound closed. Incision in right foreleg. 30 mm. of the shaft of the ulna with periosteum resected. Bone graft placed in defect with ends of graft in medullary cavities of the stumps of the resected bone. Wound closed. Plaster dressing on foreleg.

PLATE I

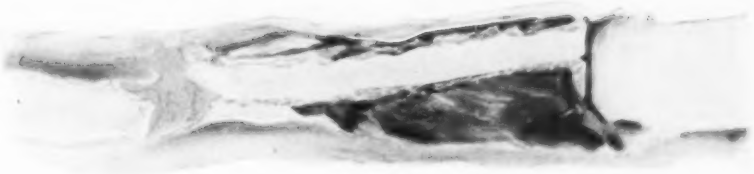

FIG. 1.—Experiment No. 27. Autotransplantation of living bone with periosteum and endosteum. The transplant is unstained. There is regeneration of bone on the periosteal and endosteal sides of the transplant. The amount of new bone formed is slightly exaggerated in the illustration.

FIG. 2.—Experiment No. 35. Autotransplantation of living bone with periosteum and endosteum. Twenty-seven days. The transplant is united to the stumps of the resected bone by callus. There is new bone formation along the entire transplant.

FIG. 3.—Experiment No. 28. Autotransplantation of living bone with periosteum and endosteum. Fifty-six days. Showing regeneration of bone along entire length of the transplant. The transplanted bone shows evidence of absorption.

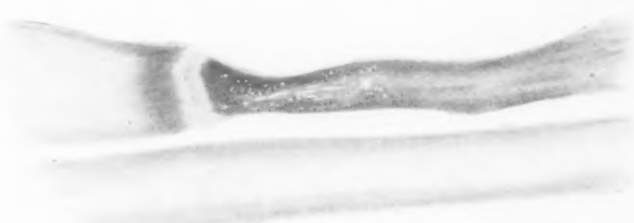

FIG. 4.—Experiment No. 45. Autotransplantation of living bone with periosteum and endosteum. One hundred and five days. Showing complete regeneration of resected bone.

The animal was given 2 c.c. of a saturated aqueous solution of sodium alizarine sulphonate subcutaneously for one week, and thereafter 3 c.c. of the saturated aqueous solution of the dye once a week intraperitoneally.

January 5, 1917, twenty-seven days. Operative wounds healed *per primam*. Animal sacrificed. There was a thin layer of pale rose-pink bone under the periosteum of all bones. There was staining of the bone on the diaphyseal side of the epiphyseal lines. The ends of the stumps of the resected ulna were red. The bone transplant was in perfect position. Each end of the transplant was joined to the stump of the resected bone by a callus. The graft was surrounded by a mass of tough fibrous tissue to which it was firmly attached. There was new bone formation along the entire length of the graft. The new formed bone was for the most part along the sides of the graft which were covered by periosteum and endosteum. There was, however, some new bone formation on all sides of the graft (Fig. 2, Plate I). Microscopic sections of the entire length of the graft and the stump of the resected ulna were prepared.

Microscopical Examination.—The sections were cut in a plane parallel to the length of the graft and perpendicular to the periosteal and endosteal surfaces of the transplant. In some parts of the transplant the lacunæ were completely empty and the bone was obviously nonviable. In other parts the lacunæ contained nuclei which had normal staining properties. Throughout the entire graft there was evident absorption of the bone by giant cells and granulation tissue (Fig. 15, Plate IV). On the periosteal surface of the transplant there was marked new bone formation (Fig. 13, Plate IV). In like manner there was formation of new bone trabeculæ on the endosteal surface of the transplant (Fig. 14, Plate IV). The transplant was united to the ends of the stumps of the resected bone by a mass of fibrous tissue. There was no evidence of continuity between the new bone produced about the transplant and that produced from the stumps of the resected ulna.

Experiment No. 28.—Adult dog. January 4, 1917. Autotransplantation of living bone with periosteum and endosteum, fifty-six days.

Incision left thigh. Bone graft 60 mm. by 2 mm. cut with motor saw from full thickness of cortex of femur. Periosteum and endosteum on graft intact. Bone graft from femur placed in defect. Ends of transplants fixed in medullary cavities of stumps of resected bone. Wound closed.

Incision in right foreleg. 40 mm. of shaft of ulna with periosteum removed. No transplant used in defect. Wound closed. Plaster dressings on forelegs.

The animal was given 3 c.c. of a saturated aqueous solution of sodium alizarine sulphonate intraperitoneally once a week. The operative wounds healed *per primam*. The plaster dressings were removed at the end of six weeks.

March 1, 1917, fifty-six days. Animal sacrificed. The bones other than those operated upon were unstained. The epiphyseal cartilages had disappeared, but the lines of junctions between epiphyses and diaphyses could be indistinctly seen. The portion of the shaft of the right ulna which was excised had not regenerated. The bone transplant in the left ulna was in perfect position. There was growth of new bone at the ends of the stumps of the resected bone. There was also some subperiosteal new bone formation along the shaft of the radius in the region of the defect in the ulna. The transplant was united to each stump by callus, which was similar to the callus formed after a fracture. There was new bone formation along the entire length of the transplant. The bone graft had lost its original outlines. In some areas it was obviously being absorbed. The amount of new bone formed was least in the middle of the transplant and most at the ends (Fig. 3, Plate I). The specimen was decalcified and microscopic sections made.

Microscopical Examination.—Longitudinal sections of the entire length of the

graft and the stumps of the resected ulna were examined. The original outlines of the transplant were fairly well defined. The transplant was obviously in the process of being absorbed. It was surrounded for its entire length by an envelope of new formed bone. The transplant and envelope of new bone were arranged similarly to a sequestrum and involucrum. In some areas of the remaining part of the transplant the lacunæ were empty. In other areas the lacunæ contained nuclei which had normal staining properties. All the spaces in the transplant were permeated by blood-vessels and connective tissue. Each end of the transplant was united to a stump of the resected ulna by fibrocartilaginous tissue.

Experiment No. 45.—Adult dog. January 11, 1917. Autotransplantation of living bone with periosteum and endosteum, one hundred and five days.

Incision in left thigh. Bone graft 40 mm. by 2 mm. cut with motor saw from full thickness of cortex of femur. Periosteum and endosteum intact. Wound closed. Incision in right foreleg. 30 mm. of shaft of ulna with periosteum resected. Bone graft transplanted into defect. Transplant fixed firmly in medullary cavities of fragments of resected bone. Wound closed. Plaster dressing.

The wounds healed *per primam*. The plaster-of-Paris dressing was removed at the end of ten weeks. The animal was given, once a week, an intraperitoneal injection of 3 c.c. of a saturated solution of sodium alizarine sulphonate.

April 24, 1917, 105 days. Animal sacrificed. All bones were a pale rose-pink color. The epiphyseal cartilage in the distal end of the ulna had almost completely disappeared. The bones indicated a young adult dog. The defect in the ulna was completely repaired by well-stained bone. There was complete regeneration of a functionating shaft (Fig. 4, Plate I). The bone was sectioned longitudinally through the grafted area. The junction of the distal fragment and the graft could only be distinguished by the differences in diameter. A medullary cavity was forming in the grafted area. The junction of regenerated area and the proximal fragment was very distinct. Within the deeply stained bone at this point there was a small area of unstained bone which probably represented the only remaining part of the original transplant. This unstained bone was clearly being absorbed in the process of the formation of a medullary cavity in the grafted area (Fig. 5, Plate II).

Microscopical Examination.—Longitudinal sections of the entire transplanted area were examined. There was complete regeneration of the entire defect. The point of union of the graft and the distal stump of the ulna could not be distinguished. The union of the graft and the proximal stump of the ulna was clearly marked by a thin disk of cartilage. No evidence of any remaining part of the original transplant could be found. Characteristic bone marrow was present throughout most of the length of the grafted area.

Experiment No. 38.—Old dog. December 14, 1916. Autotransplantation of living bone with periosteum and endosteum, fifty-five days.

Incision right foreleg. 30 mm. of shaft of ulna with periosteum resected. Wound closed.

January 4, 1917. Operative wound healed *per primam*. No evidence of regeneration of resected bone. Incision in left thigh. Bone graft 35 mm. by 2 mm. cut with motor saw from full thickness of cortex of femur. Periosteum and endosteum intact. Incision in right foreleg. Bone graft placed in defect in right ulna. Wound closed. Plaster dressing on foreleg.

The animal was given once a week 3 c.c. of a saturated aqueous solution of sodium alizarine sulphonate intraperitoneally. The wounds healed *per primam*.

February 27, 1917, fifty-five days. Animal sacrificed. All bones except those operated on showed very little or no staining. The defect in the femur was filled with new bone stained red. There was no subperiosteal new bone forma-

FIG. 5.—Experiment No. 45. Autotransplantation of living bone with periosteum and endosteum. One hundred and five days. Cross-section of the regenerated area shown in Fig. 4, Plate I. Showing the development of a medullary cavity in the transplanted area.

FIG. 6.—Experiment No. 38. Autotransplantation of living bone with periosteum and endosteum. Fifty-five days. Showing the failure of the transplant to regenerate the bone defect. Note the relatively small amount of bone regeneration from the stumps of the resected bone, and complete absence of general staining of bones.

FIG. 7.—Experiment No. 33. Autotransplantation of living bone without periosteum or endosteum. Fourteen days. Showing that there is no regeneration of bone from the transplant. Note the bridge of bone which has regenerated from the periosteum which was not completely removed at operation.

FIG. 8.—Experiment No. 42. Autotransplantation of living bone without periosteum or endosteum. Twenty-six days. Showing that there is no regeneration of bone from the transplant.

tion about the site of the excision of the graft in the femur. The bone graft in the foreleg was in excellent position. There was no new bone formation from the distal stump of the resected ulna. The end of the proximal fragment was united to the shaft of the radius by a callus. In this callus there was new bone formation. The distal end of the bone transplant had been completely absorbed. There was at the proximal end of the transplant a very small amount of new bone formation. The transplant as a whole was being absorbed, and there was no evidence that the defect in the ulna would have been repaired (Fig. 6, Plate II). The specimen was decalcified and microscopic sections prepared.

Microscopical Examination.—Section of the entire length of the graft and the ends of the stumps of the resected ulna were examined. The distal third of the transplant was entirely absorbed and replaced by fibrous tissue. In this fibrous tissue there was no evidence of bone or bone-producing tissue. The proximal two-thirds of the transplant was clearly in the process of being absorbed. The lacunæ of some parts of the graft contained nuclei with normal staining properties. In other areas the lacunæ were empty. Blood-vessels and connective tissue permeated spaces in the transplant. Near the proximal end of the transplant there was a small island of new bone formation which seemed to be derived from the transplant, but may have been derived from the stump of the resected bone. Microscopical examination confirmed the observations of the gross examination.

Experiments Nos. 26, 27, 28, 35, and 45 illustrate a series of stages of the regeneration of a defect in the shaft of a bone following the transplantation into this defect of a living bone graft with periosteum and endosteum. By means of the vital stain it was possible to determine the exact site of origin of the bone regeneration and to trace the process through successive stages to a complete restoration of the original bone shaft. Also the method of study by means of the vital stain was supplemented in each experiment by microscopical examination of the transplant.

In Experiment No. 26, in which the animal was sacrificed seven days after the bone transplantation, there was no regeneration of bone from the transplant. Microscopical examination, however, showed that portions of the periosteum and endosteum of the transplant had remained viable and that there was a proliferation of bone-producing cells from the viable areas. In Experiment No. 27, in which the examination was made fourteen days after the bone transplantation, there was regeneration of new bone along the periosteal and endosteal sides of the transplant, and the distribution of the bone regeneration equally along the entire length of the transplant without any evidence of a continuity of the new bone formed along the graft with that produced from the stumps of the resected bone was conclusive proof that the bone regeneration was from the transplant and not from the stumps of the resected bones along the course of the transplant. In Experiment No. 27, in which the specimen was examined twenty-seven days after the transplantation, there was a larger amount of new bone formed from the graft. The transplant was united to the ends of the stump of the resected bone by callus. The bone matrix of the transplant was in part clearly nonviable, and in other parts showed the microscopic picture of living bone. The bone matrix was in some areas clearly in the process of being absorbed. In Experiment No. 28, in which the

animal lived fifty-six days after operation, the regeneration of new bone and the absorption of the bone matrix of the transplant had progressed still further. Finally in Experiment No. 45, which was of 105 days' duration, the defect in the shaft had completely regenerated. The identity of the transplant had completely disappeared. A normal marrow cavity had developed in the regenerated area.

In Experiment No. 38, in which the method used was the same, and in which the postoperative course of the animal differed in no way from the other experiments in this group, there was a complete failure of the transplant to show evidence of regeneration of bone. It is significant that there was very little new bone formation at the site of the removal of the graft from the femur and from the stumps of the resected ulna. This failure of the transplant to generate new bone was due to the limited osteogenetic properties of the bone from which it was removed. The fact that the animal was an old dog explains the low osteogenetic properties of the bones.

II. EXPERIMENTS WITH TRANSPLANTS OF LIVING BONE WITHOUT PERIOSTEUM OR ENDOSTEUM

Experiment No. 33.—Young dog. December 4, 1916. Autotransplantation of bone without periosteum and endosteum, fourteen days.

Incision in left thigh. Bone graft 50 mm. by 1 mm. cut from full thickness of cortex of femur. Periosteum and endosteum removed from graft. Wound closed. Incision in left foreleg. Forty mm. of shaft of ulna resected with periosteum. Bone graft from femur from which the periosteum and endosteum was removed was transplanted into the defect. The transplant was fixed in the medullary canals of the stumps of the resected bone. Plaster dressing.

The animal was given 2 c.c. of a saturated aqueous solution of sodium alizarine sulphonate subcutaneously on alternate days. The wounds healed *per primam.*

December 18, 1916, fourteen days. Animal dead. Cause of death was intestinal intussusception. The epiphyseal cartilages were all present. There was staining of all of the bones on the diaphyseal sides of the epiphyseal cartilages. The shafts of the bones other than those operated on were unstained. There was an unusually large amount of new bone formation about the site of the excision of the graft in the femur. This new bone was stained a bright-red color. The bone graft in the resected ulna was in good position. There was marked new bone formation at the ends of the stumps of the resected ulna. The transplant showed no color. It appeared completely necrotic. It was not attached to the surrounding tissues. Between the transplant and the radius there was a bridge of new-formed bone which connected the two fragments of the resected ulna. This was clearly a regeneration from a strip of periosteum which was left along the interosseous membrane when the portion of the shaft was resected (Fig. 7, Plate II). The regeneration was entirely independent of the bone transplant. Microscopic sections of the transplant and the surrounding tissue were prepared.

Microscopical Examination.—Sections of the transplant showed the lacunæ empty and the entire transplant was obviously nonviable. There was no evidence of regeneration of bone at any point in or about the graft. The small stained spots seen in the surrounding connective tissue proved to be calcification of degenerated muscle fibres.

Experiment No. 39.—Adult dog. January 6, 1917. Autotransplantation of bone without periosteum or endosteum, twenty-one days.

Incision in right thigh. Bone graft 40 mm. long and 1 mm. wide cut from full thickness of cortex of the shaft of femur with motor saw. Wound closed. Incision in right foreleg. Thirty mm. of shaft of ulna removed with periosteum. The periosteum and endosteum were completely removed from the graft cut from the femur. The transplant was placed in the defect in the ulna. The ends of the graft were fixed in the medullary cavities of the stumps of the ulna. Wound closed. Plaster dressing.

The wounds healed *per primam*. The animal was given on the seventh and fourteenth days an intraperitoneal injection of 3 c.c. of a saturated aqueous solution of alizarine sulphonate.

January 27, 1917, twenty-one days. Animal died. Cause of death was intestinal intussusception. There was very slight general staining of the bones. The distal epiphyseal cartilage of the ulna had disappeared. The distal epiphyseal cartilage of the femur was present. There was quite a large amount of well-stained new bone formed about the site of the excision of the graft from the femur. The bone transplant was in good position. There was new bone formation from the stumps of the resected ulna. No evidence of any growth of bone from the transplant. The transplant was in part adherent to the surrounding tissue. Microscopical sections of the transplant were prepared.

Microscopical Examination.—Sections of the entire length of the graft and the stumps of the resected ulna were examined. In portions of the transplant the lacunæ contained no nuclei and the bone matrix was obviously nonviable. In other areas the lacunæ contained nuclei with normal staining properties. In many of the Haversian canals there were blood-vessels containing red blood cells. In the areas of the graft in which there were blood properties the microscopical picture was that of viable bone. There were many areas in which the transplant was obviously being absorbed by giant cells and granulation tissue. There was no evidence of bone regeneration at any point in or about the transplant. There was marked regeneration of bone from the periosteum and endosteum of the stumps of the resected ulna.

Experiment No. 42.—Young dog. January 10, 1917. Autotransplantation of bone without periosteum and endosteum, twenty-six days.

Incision in right thigh. Bone graft 45 mm. long and 2 mm. wide cut from the full thickness of cortex of shaft of femur. Wound closed. Incision in right foreleg. 40 mm. of shaft of ulna with periosteum removed. Periosteum and endosteum completely removed from bone graft from femur. Transplant placed in defect of ulna.

The wounds healed *per primam*. The animal was given, once a week, an intraperitoneal injection of 3 c.c. of a saturated aqueous solution of sodium alizarine sulphonate.

February 5, 1917, twenty-six days. Animal died. No general staining of bones. Epiphyseal cartilages were all present. There was new bone formation from the stumps of resected bone. Subperiosteal new bone formation was present on shaft of radius in region of resection of ulna, and on the femur in the region of the excision of the transplant. The transplant was in excellent position. Both ends of the transplant were fixed in the medullary canals of the stumps of the resected ulna. There was no regeneration of bone from the transplant (Fig. 8, Plate II).

Experiment No. 46.—Adult dog. January 13, 1917. Autotransplantation of bone without periosteum or endosteum, seventy-eight days.

Incision in right thigh. Bone graft 40 mm. long and 1 mm. wide was cut from the full thickness of the cortex of the shaft of the femur. Wound closed.

Incision in right foreleg. Thirty mm. of the shaft of the ulna was removed with the periosteum. The periosteum and endosteum with the adjacent layers of bone were scraped away from the graft from the femur. The transplant was placed in the defect in the resected ulna. The transplant was firmly fixed in the medullary cavities of the stumps of the resected bone. Wound closed. Plaster dressing.

The wounds healed *per primam*. The plaster dressing was removed after three weeks. The animal was given, once a week, an intraperitoneal injection of 3 c.c. of a saturated aqueous solution of sodium alizarine sulphonate.

April 2, 1917, seventy-eight days. The animal died of general peritonitis following the last injection of the dye. There was slight staining of all bones. The epiphyseal cartilages were absent, but the junctions of the epiphyses and diaphyses were all distinct. There was a large amount of well-stained new bone about area of excision of graft in femur. The bone transplant was in excellent position. There was a large amount of new bone formed at the end of the proximal fragment of the resected ulna. This new bone had grown alongside of transplant for a distance of 1 cm. (Fig. 9, Plate III). There was very little new bone formation from the stump of the distal fragment. The transplant was being absorbed. The distal two-thirds was irregular and smaller than original transplant. The transplant was adherent to the surrounding tissue. At the junction of the middle and distal thirds of the transplant there was a small island of new bone, which was not continuous with the new bone formed along the proximal third of the transplant. Microscopical sections of the entire length of the transplant and the stump of the resected ulna were prepared.

Microscopical Examination.—Longitudinal sections of the transplant confirmed the gross examination. In the transplant most of the lacunæ contained nuclei with normal staining properties. In some areas the lacunæ contained no nuclear material. Blood-vessels and connective had penetrated into many spaces in the transplant. There was no evidence of regeneration of bone from any part of the graft. At the junction of the transplant and the proximal stump of the resected ulna there was marked new bone formation. This growing bone extended along the proximal third of the graft. The sections examined did not show the small isolated island of new bone at the junction of the middle and distal thirds of the transplant. All bone regeneration seen microscopically certainly originated in the stumps of the resected bone, and the growth was along the course of the graft and not from it.

In the experiments in which living bone transplants without periosteum or endosteum were used there were very strikingly different results obtained from those experiments in which the periosteum and endosteum were not removed from the transplants. In Experiments Nos. 33, 39, and 42, in which the animals were sacrificed fourteen, twenty-one, and twenty-six days respectively after the transplantation, there was no evidence of any bone regeneration from the transplanted bone. In Experiment No. 46, in which the dog lived for seventy-eight days, there was a very small amount of new bone formed, which may have grown from the graft, but which seemed more likely to have originated from the stumps of the resected bone and grown along the course of the transplant. In this experiment there was clearly a considerable amount of new bone which had originated in the stumps of the resected bone and grown along the course of the transplant. In these experiments no old dog was used. In all of the experiments there was abundant new bone formation from the femur in the region of the excision of

FIG. 9.—Experiment No. 46. Autotransplantation of living bone without periosteum or endosteum. Seventy-eight days. Showing the growth of bone along the transplant from the proximal fragment of the resected bone. The small island of stained bone near the distal end of the graft may have originated in the transplant, but probably is a further extension of growth along the graft.

FIG. 10.—Experiment No. 37. Implantation of sterile dry bone. Eighteen days. Note the general staining of the bone in a young dog. The island of red tissue between the implant and the radius is an area of calcification in degenerated muscle.

FIG. 11.—Experiment No. 47. Implantation of sterile dry bone. Twenty-two days. There is no growth of bone about the transplant.

FIG. 12.—Experiment No. 49. Implantation of sterile dry bone. Seventy-eight days. Note the characteristic yellow opaque dead bone implant. There is no new bone formed about the implant. Microscopical section of this implant is illustrated in Fig. 16, Plate IV.

the graft. In Experiment No. 33, there was a regeneration of a bridge of bone independent of the bone transplant. This regeneration was probably from a small strip of periosteum along the attachment of the interosseous membrane which was not removed when the segment of the graft of the ulna was resected. In Experiments Nos. 42 and 46 microscopical examination of the transplant showed in parts of the transplanted bone that the lacunæ contained nuclei of normal staining properties. In other areas the transplants were clearly nonviable. In no experiment was there any evidence of regeneration of bone from the transplant.

III. EXPERIMENTS WITH IMPLANTS OF STERILE DRY BONE

Experiment No. 37.—Young dog. January 6, 1917. Implantation of dried sterile bone, eighteen days. Incision in right foreleg. 35 mm. of shaft of ulna with periosteum removed. Into the defect was placed a piece of dried sterile bone 40 mm. long, 1 mm. wide and 1 mm. thick. The ends of the implant were fixed in the medullary cavities of the stumps of the resected ulna. Wound closed. Plaster dressing.

The wound healed *per primam*. The animal was given on the seventh and fourteenth days an intraperitoneal injection of 3 c.c. of a saturated aqueous solution of sodium alizarine sulphonate.

January 24, 1917, eighteen days. Animal found dead. The epiphysial cartilages were all present. There was staining of all bones at the sites of growth. There was new bone formation at the ends of the stumps of the resected bone. The bone implant was not attached to the surrounding tissues. There was no new bone formation along the implant. In the connective tissue between the bone implant and the shaft of the radius there was a small red area (Fig. 10, Plate III). Microscopical examination of this area showed it to be calcification in degenerated muscle fibres. No microscopical examination of bone implant was made.

Experiment No. 47.—Young dog. January 15, 1917. Implantation of dried sterile bone, twenty-two days. Incision in right foreleg. 35 mm. of the shaft of the ulna with the periosteum was removed. A piece of sterile dry bone 40 mm. long, 2 mm. wide and 1 mm. thick was placed in the defect in the resected ulna. The ends of the bone implant were fixed in the medullary cavities of the stumps of the resected bone. Wound closed. Plaster dressing.

The wound healed *per primam*. The animal was given on the sixth and sixteenth days an intraperitoneal injection of 3 c.c. of a saturated aqueous solution of sodium alizarine sulphonate.

February 6, 1917, twenty-two days. Animal dead. Cause of death was intestinal intussusception. All the epiphysial cartilages were present. There was staining of all bones at the sites of growth. There was new bone formation from the ends of the fragments of the resected bone. The bone implant was in good position. There was no new bone formation along the implant. The implanted bone was not attached to the surrounding tissues, but was firmly fixed in the medullary canals of the fragments of the ulna (Fig. 11, Plate III).

Experiment No. 34.—Young dog. December 7, 1917. Implantation of sterile dry bone, twenty-eight days. Incision right foreleg. 25 mm. of shaft of ulna with periosteum removed. Into the defect in the ulna was placed a piece of sterile dry bone, 40 mm. long. The ends of the implant were thrust into medullary canals of the stumps of the resected ulna. Wound closed. Plaster dressing.

The wound healed *per primam*. During the first two weeks of the experiment the animal was given on alternate days 2 c.c. of a saturated aqueous solution of sodium alizarine sulphonate subcutaneously. During the last two weeks

of the experiment the animal was given two intraperitoneal injections of 4 c.c. of the saturated solution of the dye.

January 4, 1917, twenty-eight days. Animal dead. The epiphysial cartilages were all present. There was staining of the bones at the sites of growth. There was well-stained new bone at the ends of the stumps of the resected ulna. No color in or along the implant. The implant was not attached to the surrounding tissues.

Experiment No. 49.—Adult dog. February 8, 1917. Implantation of sterile dry bone, seventy-eight days. Incision in right foreleg. 40 mm. of shaft of ulna with periosteum excised. A piece of sterile dry bone 40 mm. long, 4 mm. wide, and 2 mm. thick was placed in the defect. The ends of the implant were in contact with the stumps of the resected ulna. Wound closed. Plaster dressing. The wound healed *per primam*. The plaster dressing was removed at the end of four weeks. The animal was given each week an intraperitoneal injection of 3 c.c. of a saturated solution of sodium alizarine sulphonate. The animal remained in good health throughout the duration of the experiment.

April 25, 1917, seventy-eight days. Animal sacrificed. There was very slight general staining of the bones. The epiphysial cartilages had all disappeared. The junction of the epiphysis and diaphysis at the lower end of the femur was distinct. There was well-stained new bone formed from the stumps of the resected ulna. There was subperiosteal new bone formation on the shaft of the radius in the region of the resection of the ulna. The bone implant was in good position. The ends of the implant were in contact with the stumps of the resected ulna. There was motion with crepitus at each end. The implant was surrounded by fibrous tissue. There was no growth of bone along the implant (Fig. 12, Plate III). Gross examination indicated definitely that the bone implant was nonviable, and there was no evidence whatsoever of new bone formation at any point along the graft. Microscopical sections of the entire length of the transplant and the stumps of the resected ulna were prepared.

Microscopical Examination.—Sections of the transplant showed a very striking picture. The lacunæ throughout the transplant contained nuclei with normal staining properties. Blood-vessels and connective tissue had penetrated into the Haversian canals. In fact, the microscopical picture of certain areas in the implant was that of normal living bone (Fig. 16, Plate IV). The implant was surrounded by a dense connective tissue capsule which in the sections examined was in contact with bone implant in only a few places.

There was regeneration of new bone from the stumps of the resected ulna. This growth of new bone had extended along the course of the graft a short distance at the distal end of the transplant. The ends of the transplant were separated from the ends of the stumps of the resected ulna by fibrocartilaginous tissue. There was evident absorption of the implant by granulation tissue and giant-cells in certain areas, but on the whole the evidences of absorption were strikingly few.

In these experiments in which pieces of sterile dry bone were implanted in defects in the shafts of bones there was in no instance any evidence that such an implant aided in any way the subsequent regeneration of the bone defect. In no experiment was it found that the implanted dry bone induced new bone formation in the surrounding connective tissue, and there was no evidence that such implants had any specific powers of conducting bone growth from the ends of the stumps of the resected bone. In Experiment No. 49 it is possible that had the animal been allowed to live a much longer

period the implant might have been slowly replaced by bone growing from the stumps of the resected ulna, but from other experimental work and clinical observations this seems improbable.

The microscopical examination of the implanted bone in Experiment No. 49 is particularly interesting. The source of the implant and the gross examination at the end of the experiment showed clearly that it was necrotic bone. Microscopical examination, however, showed that blood-vessels had grown into the spaces in the bone matrix and connective tissue or phagocytic cells had permeated the lacunæ, resulting in the production of a microscopic picture which was indistinguishable in many areas from normal living bone. This finding indicates that microscopical examination may be often misleading in determining the viability of bone. In the microscopical examination of specimens from the implantation of pieces of dead bone into soft parts in other experiments not described in this paper it has been found that in the process of absorption of such implants a microscopical picture is produced which is often actually indistinguishable from that of new bone formation. This confusion between the microscopic pictures of bone regeneration and bone absorption, we believe, may be responsible for certain conflicting conclusions which have been reached by different investigators in problems of bone regeneration.

DISCUSSION

These experiments show conclusively that a defect in the shafts of a bone may be quickly and completely regenerated after placing within the defect an autotransplant of living bone with periosteum and endosteum. The regeneration of bone to repair the defect originates in portions of the normal bone regenerating elements of the graft which remain viable. There is a question whether the transplanted bone matrix and bone cells retain their viability for a short period of time, but there is no question that the identity of the transplanted bone is ultimately lost as a result of absorption and replacement by new bone. If the periosteum and endosteum together with the adjacent layers of bone are removed from the transplant, it has no osteogenetic properties. Such a transplant may show microscopic evidence of remaining in part viable, but this evidence is uncertain. If an implant of sterile dry bone is placed in a defect in the shaft of a bone there is no evidence that such an implant aids in any way the regeneration of the defect. The implanted dead bone neither results in a metaplastic production of bone from the surrounding tissue nor does it possess any specific property of conducting bone growth across the defect in the bone shaft. These facts clearly indicate that the living bone transplant with the periosteum and endosteum is the only type of implant which has osteogenetic properties. It is possible that a defect in the shaft of a bone may be regenerated by the growth of bone along the course of a transplant when the transplant itself has no osteogenetic properties, but this is a relatively

slow process, and it will take place only in case the defect is small and there is active bone regeneration in the fragments of the bone shaft in which the defect occurs. The osteogenetic properties of a free bone transplant vary quantitatively with the potential osteogenetic properties of the bone from which the transplant is taken. In this experimental work the factor which seemed to influence the power of bones to regenerate was the age of the experimental animal. Clinical experience shows that there are other factors.

We believe it is no longer a matter of question that the preservation of the periosteum and endosteum on a free bone transplant is the most important factor in determining the success of the transplant. The explanation of this fact is not yet clear. The following three explanations have been given: (1) The periosteum serves to direct and protect new bone growth. (2) The periosteum aids in securing early nourishment for the transplant. (3) The periosteum is the osteogenetic element of the bone transplant.

The first two explanations are based on the assumption that osteogenesis originates in the bone cells of the cortical bone. We believe that the greater weight of experimental evidence is to the contrary. It is interesting, however, that in experiments in which free transplants of periosteum alone have been used there has been regeneration of bone in a relatively small proportion of instances. It seems therefore that the osteogenetic power of the free bone transplant depends on the preservation of the normal relation of the different elements of the transplant. In other words, osteogenesis is from the junction of the periosteum and cortical bone rather than from either alone. The same statements which have been made concerning the periosteum apply to the endosteum.

The influence of "functional demand" on the survival and growth of the free bone transplant is a subject which deserves brief comment. In all experiments described in this paper the transplants were placed in sites where bone is normally present. It has been found in other experiments in which transplants of bone with periosteum and endosteum have been placed in sites in which bone is not normally present, that the transplant first shows evidence of bone regeneration, but later this regeneration ceases and ultimately the transplant is completely absorbed. These facts indicate that there are both external and internal factors which determine the regeneration and growth of bone from a free bone transplant. The power of a free bone transplant with periosteum and endosteum to regenerate bone is an intrinsic property. The ability of the regenerating bone to continue the production of new bone until a functioning bone is completed is determined by external influences. The term "functional demand" may be applied to the combination of the external influences.

The practical application of the observations in this experimental study is so obvious that it requires little comment. The free bone transplant with the periosteum and endosteum is certainly the only type of implant which may be expected to be the source of new bone formation. An implant of

sterile dry bone or a transplant of living bone without periosteum or endosteum may be used as a means of fixation, or, in cases of small defects in bone, such an implant may ultimately accomplish the desired result of regeneration of the defect by being absorbed and replaced by new bone which originates from the bone adjacent to the implant. This result will not be accomplished in case the defect is large or the adjacent bone has little osteogenetic power. The osteogenetic power of a free bone transplant varies with the age of the individual, and general constitutional condition. The results of bone transplantation in children are more likely to be good than in cases of old or poorly nourished individuals.

The fact that in clinical surgery the necessity often arises of bridging a bone defect in a patient in which there is evidence of little power of bone regeneration suggests the possibility of devising means for increasing the osteogenetic power of the transplant. Two possibilities have seemed to be worth investigating experimentally. These are as follows: 1. The possibility of using a transplant from another individual in which there is greater potential power of osteogenesis. 2. The possibility that the osteogenetic power of the graft may be increased by causing artificial injury to the bone from which the graft is to be taken and thus causing new bone formation and subsequently transplanting the growing bone.

Experiments are now in progress to determine the value of these methods.

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THE COMPLETE MASTOID OPERATION*

ITS RELATION TO THE MODERN HEALING OF MASTOID WOUNDS

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The procedure about to be described as the complete mastoid operation has been performed by the writer upon some 113 patients. My purpose in using this technic with its associated after-treatment is:

1. To prevent as much as possible the development of those serious intracranial and other complications which sometimes follow an inflammation of the mastoid or an operation for its relief.

2. To reduce the time required for the healing of the mastoid wound.

3. To render the dressing as painless as possible.

4. To improve the appearance of the healed wound.

In order to satisfy these four postulates and estimate the true value of an additional step in the technic of such an orthodox procedure as the simple mastoid operation, it is necessary (1) that the surgeon should employ this technic in a large number of operations; and (2) he should observe in a general way the post-operative course of at least an equal number of patients operated upon and treated according to other methods.

The cases upon which this paper is based are not selected ones. With few exceptions, they represent the total number of mastoidectomies performed by the author in the past few years. Practically all the operations took place at the New York Eye and Ear Infirmary or at the Manhattan Eye, Ear, and Throat Hospital.

Of these 113 patients, one developed sinus thrombosis on the seventh day of convalescence, and was successfully operated upon. In 23, well-marked perisinus or epidural abscess was present; all recovered. Subperiosteal abscess was present in 18 cases. Two patients developed erysipelas during convalescence—one a man and the other a woman; this complication appearing on the tenth and nineteenth days respectively. Streptococcus was the infective agent most commonly found, being present in 48 cases; seven were of the capsulatus variety; one patient died. One patient, an alcoholic, died of delirium tremens. Three patients of the 113 developed post-operative meningitis of otitic origin, and died. The first symptoms of this fatal complication appeared in these three cases on the second, third, and tenth days of convalescence, respectively. In one of these fatal cases neither sinus nor dura was exposed, the infecting organism in this instance being the streptococcus capsulatus.

Dura covering the sinus or brain was exposed in 46 of these operations. There was a total of four deaths in these 113 cases, one of which bore no

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relation to the mastoid disease. In regarding this mortality, it must be remembered that these patients practically represent successive cases, many of which were brought to the hospital in advanced stages of mastoid disease. The three cases of meningitis occurred in young male adults, one of whom had a subperiosteal abscess of several weeks' standing containing gas. In the other two fatal cases, the mastoiditis was produced by an encapsulated organism, one a streptococcus and the other a pneumococcus. One of these patients, prior to the operation, developed symptoms of what might have been a beginning meningitis.

The usual time required for the complete healing of the wounds varied from three to five weeks. A number of cases healed in less than this time, some requiring slightly over this period. Owing to the light packing of the mastoid wound, the dressings are much less painful than is usually the case. After the healing, the wound presents little if any deformity, the depression being scarcely noticeable.

Operative Technic.—In making the incision for this operation, it is necessary to curve the upper extremity until it is directed horizontally forward, terminating in a point about one-eighth of an inch above and in front of the superior attachment of the auricle. (See Fig. 1.) This incision is usually carried through the lower edge of the temporal muscle along the line of the external wound. The cut in the muscle is on the bias of its fibres and is between one-eighth and one-fourth of an inch in depth. Anterior to this cut, the external surface of the temporal fascia is free from the auricle. The underlying periosteum is elevated. On retracting the soft parts, there is a wide and free exposure of the entire zygomatic region. These preliminaries are essential to the free exposure and curettement of the attic region. I have never found that this incision into the temporal muscle resulted in its infection or in any impairment of its function.

The bony mastoid cortex and subcortical cells are then removed, together with the tip and the cells over the knee of the sinus; the antrum is opened and curetted; the zygomatic cells are removed, and the cap of the external semicircular canal is exposed. All gross evidence of disease having been removed from the mastoid, the operator is ready for the third stage, namely, the curettement of the attic of the middle ear (see Fig. 2).

At this point, it may be well to review the surgical anatomy of the epitympanic region. The attic of the tympanum is that portion of the middle ear cavity which lies above the level of the tympanic membrane. It contains the head of the malleus and the greater part of the incus. These two ossicles articulate in about the middle of the attic. Running upward from the head of the malleus to the vault of the attic is the superior ligament of the hammer, and proceeding forward from the neck is the anterior ligament. The malleo-incudal body, with the superior and anterior ligaments of the malleus, divide the epitympanum, surgically, into two cavities—the internal attic, lying internally to these structures, and the external attic, lying externally. The external attic is still further subdivided by the

external lateral ligament of the malleus into Prussak's space, which lies below, and a much larger space above, the external attic proper, with which we are now concerned.

When curetting the attic of the tympanum, the external attic should first be cleared out and the malleo-incudal body exposed, after which the internal attic may be safely curetted. In curetting the external attic, a small narrow Spratt curette is passed from the antrum directly forward until the spoon rests immediately behind the bony external attic wall. The long axis of the curette should be passed parallel to the same plane as the external semicircular canal and held slightly above it (Fig. 2). By observing these precautions, we insure the entrance of the instrument into the external and not the internal attic. The short process of the incus lies directly below and external to the spoon, and by keeping the edge of the curette in close apposition to the bony external attic wall there is no danger of disturbing the malleo-incudal body lying slightly in front and internal to the back of the curette.

The external wall of the attic is then removed by curetting directly outward, the direction of motion being still in the same plane as the external semicircular canal. The posterior bony canal wall is lowered to within about one-quarter of an inch of the membrana tympani, and is reduced in thickness. The short process of the incus should then be visible. It is commonly found embedded in granulation tissue, but is always just below and anterior to the cap of the external semicircular canal, resting in the fossa incudis (see Fig. 3).

We now continue to remove the external attic wall by curetting in the aforesaid manner until the body of the incus and the head of the malleus is exposed (Fig. 4). In fact, in the latter stage of this portion of the operation, the curette has been in contact with the anterior wall of the attic.

With the attic thoroughly exposed and the malleo-incudal body freely visible, it is a simple matter to curette the internal attic. In all the cases of mastoiditis that I have operated upon, I have never failed to find the attic region filled with granulation tissue.

Post-operative Care and Dressing.—Usually, at the conclusion of the operation, an iodoform gauze drain (from four to six inches long and one inch wide, doubled once) is laid down to the antrum region; more recently, plain sterile gauze has been employed, giving somewhat better drainage. The external auditory canal is packed snugly with a narrow strip of plain gauze dipped in saline solution. The posterior wound is sutured from above down to within the last half or three-quarters of an inch, and a copious wet saline dressing is applied externally. This is continued for the first week or ten days, after which a dry dressing is used. Boric acid ointment or vaseline applied to the auricle and adjacent skin prevents maceration of the cutaneous surface. Daily dressings are performed until the wound has almost healed. This usually takes place within three to five weeks from the time of operation. Half of the sutures are removed on the first day after the operation, and the remainder on the second day. The canal is packed

FIG. 1.—The primary incision. Its upper extremity is directed horizontally forward.

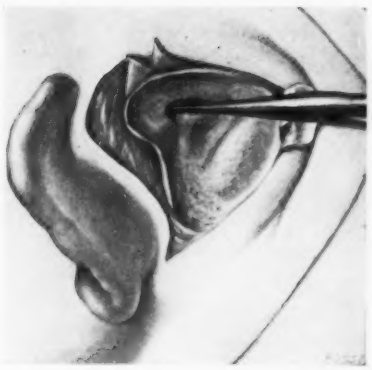

FIG. 2.—Appearance of wound at the conclusion of the simple mastoid operation. Curette in position about to remove the external attic wall. The horizontal semicircular canal is visible just below and parallel to the narrow extremity of instrument shank.

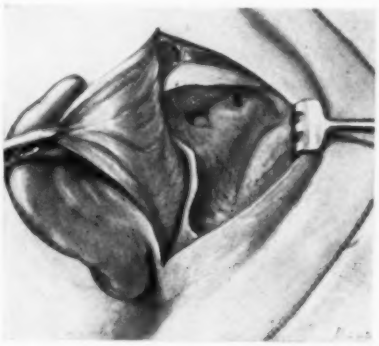

FIG. 3.—The external attic wall partially removed, revealing the body and short process of the incus lying in the "fossa incudis" just below and anterior to the prominence cap of the horizontal semicircular canal.

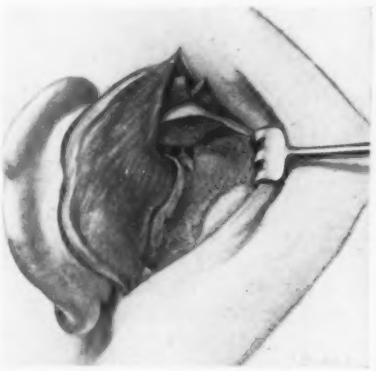

FIG. 4.—Appearance of wound at the conclusion of a complete mastoidectomy. The external attic wall has been removed, the head of the malleus with its superior ligament can be seen anterior and internal to the incus. The internal and external attic spaces lie respectively on the inner and outer sides o the malleo-incudal body.

snugly at each dressing, and the posterior gauze drain is usually discontinued between the fourteenth and the twenty-eighth day. Owing to the small amount of packing used in the mastoid wound, the dressings are comparatively painless. After healing has taken place the amount of post-aural depression is usually very slight,—in fact, hardly noticeable.

The functional results have been in every way satisfactory. So far as known, none of the patients has had to undergo operation for recurrent mastoiditis.

The writer wishes to emphasize the importance of packing the wound lightly, particularly the antrum region. Gauze packed tightly in the mastoid wound not only results in insufficient drainage therefrom, but is, in the author's opinion, the most common cause of delayed healing and depressed cicatrices. This is especially true in cases where a thorough operation has been performed.

A striking feature of the post-operative course of these patients is the rapidity with which a long-continued and profuse middle ear discharge ceases. The external auditory canal usually becomes dry on the second day. My own belief is that the failure to curette the attic region is frequently the cause of the persistent otorrhœa which sometimes follows a simple mastoidectomy.

CONCLUSIONS

1. It is the writer's conviction that in order to satisfy the requirements of his four premises it is necessary to perform all mastoidectomies as thoroughly as possible.

2. He believes that the exposure and curettement of the attic region has a direct beneficial bearing on the post-operative course of these patients.

3. That light packing of the wound, using only sufficient gauze for drainage, together with daily dressings, is essential in obtaining a satisfactory result.

4. In respect to the painful dressing, slow healing, and frequent poor cosmetic appearance, the simple mastoid operation is one of the most unprogressive of modern major surgical procedures, and any technic which promises to safely modify these distressing factors of convalescence deserves the serious consideration of otologists.

DISLOCATION OF THE CERVICAL VERTEBRÆ

REPORT OF TWO INSTANCES COMPLETELY REDUCED MANUALLY WITHOUT ANÆSTHESIA

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MAJOR, M. O. R. C., U. S. ARMY, ON ACTIVE SERVICE

Case I.—H. F., Lance Corporal in the First Dorsets, thirty years old. On July 10, 1916, while sitting on the edge of a trench, was plunged headlong into the trench by a nearby concussion. He struck on the left side of his head and left shoulder. As near as he could recall, his head was twisted to the right. He was buried in the debris of the explosion for some hours and at first, after being dug out, he could not move his legs. After two hours, however, motion returned and he was later able to walk.

On July 12, 1916, he was admitted to my service at the Twenty-third General Hospital, British Expeditionary Force, as an ambulatory patient, holding his head stiffly, chin toward the right shoulder (see Fig. 1). There was complaint of some headache, but no pain in the arms or legs, no paralyses and no evidence of involvement of the cranial nerves. Recognizing the serious character of the injury, I ordered him to bed at once. Pain radiating down the left shoulder and arm developed later and was constant. After a day a skiagram was made in both anteroposterior and lateral planes and there was proven a dislocation of the fifth cervical vertebra, rotatory in type, the left side having moved forward, the right side slightly backward. Beneath the angle of the jaw and behind and beneath the left sternocleidomastoid muscle could be felt the bony mass of the forward displacement. On the right side there was no distinct finding of bony deformity. The skiagram was not quite definite enough to establish the fact of fracture of any part of the vertebræ in this region, but it was suspected. Pharyngeal examination with the index finger demonstrated a bulging on the left posterior wall, evidently bony, and about the level of the fifth cervical (see Fig. 2).

We had no leather traction harness and as no improvement followed rest flat in bed with injunction to the patient not to turn the head, I decided to attempt manual reduction. On July 18, the deformity seeming to have slightly increased, I tried reduction. Placing the patient in a sitting position in bed, grasping the head beneath the occiput and chin, I was enabled, by forcible extension which nearly lifted his whole body weight, to make rotation and correct the deformity. A very slight jar was perceptible. After gently relaxing my grasp, I was surprised to see the head slowly but surely return to its former deformed position, without any snapping sound or subjective sensation, and without increased pain. Some new pain did develop down the middle of the back, but no untoward symptoms appeared.

A great rush of work followed this reduction and I was unable to perform anything in the line of a permanent treatment until August

FIG. 1.—Dislocation of fifth cervical vertebra. Note bony mass beneath sternocleidomastoid muscle and rigidity of neck.

FIG. 2.—Back view of same patient as Fig. 1. Notice the tilting of the head and absence of prominence in right side of neck.

FIG. 3.—Same patient as Fig. 1, enclosed in plaster helmet, deformity corrected; head in slight extension.

FIG. 4.—The second patient. Note the bony deformity beneath the right side of the neck, the tilted, rigid head, and the direction in which the chin points. The head in this instance is inclined to the left, the chin points toward the left shoulder away from the unilateral right-sided dislocation.

FIG. 5.—Side view of the preceding, showing the angle at which the head was stiffly held.

15. Although I twice repeated the manual reduction and observed the same swinging back into deformity without disaster, it was not until a month after the first reduction that we were enabled to apply a plaster-of-Paris encasement to hold the head in a slightly over-corrected position with some extension. The jacket applied (see Fig. 3) was rather heavy but served its purpose well, being anchored firmly on the padded shoulder and chest. When it was thoroughly dried, it became so light that he was able to get up and walk about. Shoulder and neck pain became greatly lessened within forty-eight hours and then disappeared. The pharyngeal displacement became corrected and I was unable to obtain a post-reductive skiagram on account of the thickness of the plaster and the lack of penetration power of our X-ray. Because all symptoms improved, the man was sent to England in the case some time later and I have been unable to follow the ultimate outcome.

CASE II.—Miss G., nineteen years old, a nurse in active training, on awakening early one morning, twisted her head to the left and used her left arm to reach under the pillow for her watch. There was some sudden pain down into the left side of the neck and shoulder and she found that her head was held rigidly turned thus (see Fig. 4). No other symptoms were present. Later pain developed in the distribution of the second, third and fourth cervical nerves, also down into the right arm.

A skiagram demonstrated the suspected rotatory dislocation displacement of the third cervical forward on the right side, unilateral in character. Pharyngeal examination was negative, no fracture could be discovered and there was bony projecting deformity to be felt beneath the right sternocleidomastoid, pressure on which was painful. I made an attempt at manual reduction in this instance also within twenty-four hours, the patient sitting on a low stool. By the same manœuvre of traction on occiput and chin, followed by rotation during its maintenance, I was able to establish a complete reduction without palpable jar. The head was then moved over into a slightly over-corrected position and a similar plaster dressing was applied. After it was dry the patient was allowed to go to her home in another state.

Four weeks later she returned, the case was removed, and immediately she was able to move the head and neck freely without pain or recurrence of deformity. She is now at work with no evidence of the injury.

Instances of cervical fracture-dislocation are not rare, but those which have occurred without serious symptoms and have been reduced by manipulation, especially without anæsthesia, are so uncommon that they should be recorded. The neck, above the vertebra prominens, requires more mobility for functional use than any other part of the spine. This mobility is secured with some sacrifice to safety because to procure the latitude of motion the vertebral articular surfaces are less oblique and are directed slightly downward, outward and forward. One must also remember that there are no steadying ribs in the neck, and, because the lax ligaments permit head rotation of at least 30 degrees on either side of the centre line, much

of the neck's rigidity and safeguarding of the spine's integrity depends on constant tonic muscular action. Sudden blows and jars will account therefore for most of these dislocations, but muscular action alone may be the cause, as in the second instance recited here. If violence is applied when the muscles are not tensely on guard, the other factors mentioned permit the "flying start" mechanism so well described by Corner (ANNALS OF SURGERY, xlv, 9). A unilateral and backward dislocation caused by the rough manipulation of an osteopath was reported by Jonas (*Trans. Amer. Surg. Assoc.*, xxxiv, 34–466).

Five instances of *total* lower cervical dislocations were recorded by Quetsch (*Munch. med. Wchnschr.*, 1912, No. 18, S. 180). Four of these were forward about the level of the fifth and sixth cervical, one was posterior. Two had hæmatomyelia with recovery. Partial or unilateral dislocations are more commonly observed and of course offer a better prognosis. Griffith (*Amer. Jour. Orthop. Surg.*, vol. xii, 332) described three instances, one of which reduced itself under morphia. The other two were successfully restored to normal by manipulation. In the discussion of his paper, six additional instances were brought to light.

Prognosis must be governed by the pathology present, *i.e.*, by the degree and direction of direct displacement, the support afforded after displacement has taken place and the subsequent progressive condition. Unilateral displacement forward without serious cord symptoms offers reasonable hope of complete reduction and restoration to normal. One must not overlook *delayed* symptoms following hæmatomyelia or spondylitis. In the twenty instances studied by Corner, two atlas dislocations were immediately fatal and none of the remainder presented symptoms *at first*. Cord symptoms may develop after varying periods from a few days to a year or more, depending on progressive pathology or subsequent dislocation dependent on the primary injury. Wilson mentioned (ANNALS OF SURG., xlv, 632) a brakeman who fell from a train, suffered a fracture-dislocation of the atlas without symptoms of cord injury, and worked quite steadily for a year afterward. He was first seen and examined three years after the accident, pain in the head and neck having caused him to discontinue work after one year. There was considerable spondylitis present and the axis was found well tilted forward but there were no cord symptoms. It was supposed that this man had suffered a primary dislocation with an instantaneous reduction and that the subsequent spondylitis had induced a secondary partial dislocation. Ryerson (*Amer. Jour. Orth. Surg.*, 1910, 342) obtained a reduction for his patient by anæsthesia and manipulation, the third cervical having been dislocated on the fourth. One instance of subluxation of the atlas on the axis, possibly similar in mechanism to the second one mentioned here, was caused by the act of pitching a baseball. Ogilvy (*Amer. Jour. Orth. Surg.*, xii, 314) saw the patient a month later but was unable to obtain reduction with the aid of anæsthesia. Eccles reported last year (*St. Barth. Hosp. J.*, London, xxiii, 101) two instances of cervical dislocation without death.

When reduction is not possible with or without anæsthesia, recourse may be had to laminectomy for pressure pains on the nerve roots. Rochfort (*Boston M. and S. Journal,* clxxiv, 469) performed this operation after dislocation of the second cervical.

Briefly the symptoms and diagnosis may follow the history of a blow or violence applied to the head or a sudden muscular action involving the head and neck generally without symptoms of paralysis or anæsthesia (cord involvement) in the unilateral rotatory displacements. The neck at or about the point of displacement is painful to palpation, it is held stiffly and head can be moved little. Some motion is generally possible unless the dislocation is total—the deformity also going hand in hand with the relative amount of displacement. As in Fig. 1 the head is usually flexed and turned to one side and in severer displacements it is bent toward the shoulder except when the displacement is posterior. The chin as a rule points toward the side *away* from the inclination of the head and the head can be rotated more to that side than the other. We know that the side toward which the chin is directed is that on which the transverse process of the cervical vertebra is either intact or is displaced backward. Attempts to rotate the head soon discover to which side it cannot be turned and it is on this side that the dislocation, partial or complete, has occurred. The articulation of the joint on this side has become fixed by the displacement and rotatory muscular action. If the head is extremely rigid and will not permit motion more in one direction than another—all movements of course being attempted with the greatest caution—we must diagnose a bilateral displacement. Bony prominence in the neck is usually on the dislocated side. Pharyngeal examination along the posterior wall when the mouth can be opened confirms the other findings. Lateral skiagrams are absolutely necessary to arrive at a complete röntgenologic diagnosis.

In uncomplicated unilateral cervical dislocation displacements, I wish to advise a careful attempt at reduction without anæsthesia, with cöoperation of the patient to enable the operator to observe the onset of untoward symptoms. A complete helmet case should be installed for from four to six weeks to insure ligamentous healing before the head is entrusted to its own musculature again.

TUBERCULOSIS OF THE APPENDIX

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Tuberculosis of the appendix is one of the more rare manifestations of tuberculosis in the human body. Since the recognition of the disease by Corbin [1] in 1873, it has only occasionally attracted the attention of the physician and surgeon. With the discovery of the tubercle bacillus by Koch in 1882, added zest was given to the study of tuberculous lesions in general, and in the last few years tuberculosis of the appendix has been accorded greater attention. However, the comparative rarity of the condition is indicated by the fact that the Index Catalogue of the Surgeon General's Library and the Index Medicus present but forty-four articles upon this subject, nine of which the physicians of the United States have contributed. This fact stands in marked contrast to the thousands of papers which have been written upon the general subject of appendicitis. The larger text-books on pathology and even the extensive systems of medicine and surgery accord only passing mention to the lesion or entirely neglect it.

While the opinions of different medical writers vary somewhat as to the frequency of the disease, all are agreed that it is relatively infrequent. Deaver, of Philadelphia, considers it among the greatest rarities, while Lockwood, of England, considers that two per cent. of all diseased appendices are tuberculous. In the Montreal General Hospital in a series of 1259 appendicectomies, there were found but three appendices showing tuberculous involvement, giving a percentage of but 0.16. In Allen's [2] series of 80 cases, tuberculosis was twice noted. In my series of 179 appendices studied histologically, only one case was discovered. The frequency of tuberculosis in appendices removed by operative procedure is much less than that in appendices removed at post-mortem examinations, as may be seen by a reference to Tables I and II.

TABLE I

Frequency of Tuberculosis of Appendix Found at Operation

Operator	Year	Operations	Tuberculous	Per cent.
Fitz	1886	257	8	3.0
Robson	1902	300	5	1.7
Letulle	1905	300	2	0.7
Mayo	1905	1888	29	1.5
Surg. Lab., U. Penn.	1909	310	6	2.0
Deaver	....	7610	16	...
Allen	1909	89	2	2.8
Author's series	1917	179	1	0.57

[1] Müller: Univ. Penn. Med. Bull., 1909–1910, xxii, 48–54.

[2] Allen: Brit. J. Child. Dis., 1909, vi, 1–7.

TABLE II

FREQUENCY OF TUBERCULOSIS OF APPENDIX FOUND POST-MORTEM

Operator	Autopsies	Tuberculous	Per cent.
Fenwick and Dodwell	2000	17	0.8*
Leseur	500	144	22.0
Kelly	3770	44	1.2
White (cases dying in Phipps Institute as probably tuberculous)	263	57	21.7
White (cases dying in Phipps Institute as probably tuberculous)	56	33	59.0†

*Primary tuberculosis of the appendix
†Examined microscopically

The disease is more common in males than in females, the ratio being as three is to two. Most of the cases found in the literature have occurred in young adults. The following table from a paper by Müller shows the age incidence.

TABLE III

AGE INCIDENCE

Years	Cases
2 to 9	3*
10 to 19	18
20 to 29	21
30 to 39	16
40 to 49	6†

*The earliest recorded case occurred in a child of two years.
†The oldest recorded case occurred in a man of 47 years.

The disease occurs in two forms, primary and secondary. The primary form of the disease is very rare. The existence of the primary form has been denied by many writers, but Beck [3] reported a case where the removal of a tuberculous appendix was followed by death of the patient. An autopsy was performed and absolutely no evidence of tuberculosis was found elsewhere in the body, except in the lymphatic nodes of the ileocæcal angle, which were of a decidedly recent origin and were held to be secondary to the appendiceal lesion. The primary form of the disease may originate through (1) the deposition of the bacilli from the contents of the intestinal tract itself, (2) from the peritoneum, (3) from the lymphatic system, and (4) from the circulating blood. Deposition of bacilli from the fæcal content of the intestinal canal itself seems to most observers to be the most rational conception of the etiology of the primary form, since it would be extremely rare for bacilli free in the peritoneal cavity or in the general lymphatic or blood circulation to elect the appendix alone as a seat of infection, while sparing other equally vulnerable organs. The dependant position of the appendix with its tendency toward fæcal stasis affords the bacilli in the fæces a favorable opportunity for becoming implanted and developed, and hence favors the theory of an intestinal origin of the disease.

[3] Beck: Volkmann's Vortrage, 1898, No. 221.

The secondary form of the disease is much more common. It may arise by the direct extension of the process from adjacent tuberculous structures. The most frequent point of extension is from an adjacent ileocæcal tuberculosis. Direct extension may also occur when the appendix becomes adherent to tuberculous adnexa in the female. By means of the blood stream, the appendix may become infected from a focus in a distant organ, especially from a pulmonary focus. It is even asserted that the appendix may be invaded thus by bacilli from a pulmonary focus, while the intestinal tract itself entirely escapes.

Tuberculosis of the appendix occurs in one of three types; miliary, ulcerative, and hyperplastic. In the miliary type, the disease is usually manifested in the form of miliary tubercles on the peritoneal covering of the appendix. The majority of such cases appear as a part of a generalized or localized peritoneal tuberculosis, and should not strictly be classed as appendiceal lesions. Of course, it is possible that bacilli might penetrate from the fæcal content of the lumen, permeate the walls and develop nodules on the peritoneal surface, but in such cases there would be great likelihood of the development of the ulcerative form in the mucosa and submucosa.

The ulcerative type is the most common form. It may be primary, but usually is secondary to either ileocæcal involvement or tuberculous lesions of the lungs. Often it is not recognized before the microscopic examination of the excised organ is undertaken. The appendix is somewhat thicker than the normal organ. The serous coat is usually injected and frequently presents very fine adhesions. At times, however, one finds small grayish-white tubercles on the serosa. The mucosa is injected and presents small round or oval ulcers of varying extent. These ulcers may show minute tubercles in the floor, or the floor may be caseous. The ulcers are most often found near the tip of the organ, next in frequency at the base, while the intermediate portion most frequently escapes. These points of localization correspond to the points of greatest liability to fæcal stasis. The ulcers extend through the mucosa into the submucosa. At times the floor of such an ulcer is formed by the muscular coat. Perforation of the appendix is rare, but occasionally a ruptured tubercle on the serosa becomes the point of origin for a peri-appendicular abscess. Microscopically, the characteristic lesions of this type are confined to the mucosa and the submucosa. Here endothelial leucocytes and giant cells occur, with greater or lesser caseous destruction of the mucosa. Simultaneously the mesoappendix may show miliary tubercles and the adjacent lymph-nodes may be involved.

The hyperplastic type is usually secondary, there being but two cases reported in which the disease was primary. The appendix is usually somewhat enlarged, the thickening of the walls being accompanied by the deposit of fibro-adipose tissue beneath the serosa. The thickening involves the entire circumference of the organ and merges gradually with the normal areas. At times cicatrical contractions and adhesions cause a narrowing or even a stenosis of the lumen. The serosa is unchanged, but through it

one may see the discolored areas in which the subserous tissues have degenerated or become the seat of hemorrhage. Rarely miliary tubercles are found on the serosa. The mucosa is usually slightly involved, but may present a few tubercles or a few ulcers. The chief alteration occurs in the submucosa, which is greatly thickened and presents numerous tubercles in all stages of development and degeneration. There is a predominence of fibrous connective tissue and the process extends through the muscular layers in such a manner that often the separate tissue layers become indistinguishable. Microscopically, one sees a great increase in connective tissue, a blending of the layers, giant cells, fewer endothelial leucocytes, and less caseation than in the usual tubercle. By appropriate staining methods, tubercle bacilli may usually be demonstrated. The development of the hyperplastic form is considered to be due to the fact that the patient possessed a high index of resistance, whereby reparative or restrictive processes are developed around the tuberculous lesion, resulting in fibrosis. Likewise the absence of the high index of resistance results in little protective mechanism being developed, with the formation of the more rapidly destructive type of the disease.

The signs and symptoms of tuberculous involvement of the appendix show considerable variation in different patients. They fall into two groups; (1) Those referable to the tuberculous process as a pathological entity, and (2) those referable to the appendix itself. The general symptoms include the characteristic temperature of tuberculosis, usually rising two to three degrees during the afternoon, falling during the night to normal or nearly so in the morning. In some cases, there are no marked temperature changes, except during the exacerbations of the disease. In the majority of cases the pulse is somewhat accelerated. As in tuberculosis in other parts of the body, so in tuberculous appendicitis we usually find slight but progressive loss of weight. Nocturnal sweating occurs, but less frequently than in pulmonary involvement. The appendiceal disease is characterized by its extreme chronicity, which may frequently be interrupted by acute exacerbations. The appendiceal symptoms in the intervals between exacerbations present a vague sense of discomfort in the iliac fossa with slight tenderness. During the acute attacks, nausea and vomiting may occur. There may be marked muscular rigidity in the right lower quadrant. There may be slight meteorism. The characteristic point in tuberculous appendicitis is a history of recurrent attacks of appendiceal colic in which the distress of the patient is much less than is ordinarily found in acute appendicitis. Occasionally in individuals possessing rather thin abdominal walls, the appendix may be palpated as a thickened fibrous cord, at other times an irregular hardened mass is found in the region of the ileocæcal junction. In cases where the appendix is secondarily involved, the symptoms due to the primary focus will also be evident.

The clinical diagnosis of the disease is difficult, and most diagnoses have been made during operation, at autopsy, or on the microscopical examination of the organ after its removal. The presence of a history of " chronic

appendicitis," associated with a slowly progressive loss of weight, afternoon temperature and nocturnal sweating should suggest the possibility of this condition. Blood examinations during the acute attacks are of relatively slight value, as there may be either a leucocytosis or a leucopænia. If there is mixed infection superimposed, there may be leucocytosis. In uncomplicated tuberculosis there may be leucopænia. Bloodgood has remarked that in chronic cases without the active formation of pus, the leucocyte count generally lies below normal. This has been disputed by other observers, but the general opinion is that the white count is never very high in uncomplicated tuberculous appendicitis. The use of tuberculins has proven of no assistance in reaching a diagnosis. The finding of tubercle bacilli in the fæces would be of some assistance, provided one could exclude the possibility of swallowing tuberculous sputum and the presence of intestinal tuberculosis.

Clinically the question of a differential diagnosis rarely arises, since tuberculosis of the appendix seldom enters the mind of the physician at this time. In chronic cases, tuberculosis would be separated from chronic non-tuberculous involvement by the greater chronicity, the presence of an afternoon rise in temperature, loss of weight, and lesser degrees of prostration. It is recognized from suppurative appendicitis by the mildness of the attacks, absence of leucocytosis, absence of sustained hyperpyrexia, and by the lesser degree of fixation of abdominal muscles. At operation, it is differentiated from neoplasm by the fact that the tuberculous enlargement of the organ merges gradually with the neighboring healthy tissue, while a neoplasm is more localized and the transition from the pathological to the normal tissue is abrupt and demonstrable to the eye and finger.

The disease may be complicated by a peri-appendicular abscess, caused by the proliferation of the colon bacillus through the appendiceal walls. The rupture or the perforation of the ulcerative type may result in a peri-appendicular abscess of the form known as "cold abscess." A more common complication is the finding of a generalized tuberculous peritonitis, in which case care must be exercised to determine whether the appendiceal lesion is secondary to the peritonitis. Ileocæcal tuberculosis is often found in connection with this disease. It is usually secondary to the appendiceal lesion, rather less frequently the appendiceal lesion is secondary to the ileocæcal process. In advanced cases the mesenteric and ileocæcal glands may be involved.

The prognosis in tuberculous appendicitis varies according to the variety of the disease and the complications that are present. The operative mortality is very small, although the final results are not entirely favorable. In 66 cases collected by Müller, one death resulted directly from the operation, while 15 others died within a few months following operations. In fact, but 8 cases are definitely reported in the literature as cured. A cure should not be assumed until two or three years have passed following the operation. If the disease is primary in the appendix and if the operation is done before secondary involvement occurs, the operation should offer

strong hope of complete cure. Secondary tuberculosis of the appendix offers a very dismal prognosis. When the process is secondary to pulmonary involvement, especially with coincident intestinal lesions, the prognosis is grave. The prognosis is somewhat more favorable in the hyperplastic type of the disease.

The treatment falls into two subdivisions, medical and surgical. Medical treatment is permissible only in secondary type of the disease, and then only in cases where the general disease is active and progressive. If the general disease is quiescent, operative measures should always be undertaken. The condition of the lungs should be made the criterion by which the advisability of the operation is decided. Advanced pulmonary tuberculosis is an indication for medical and hygienic treatment, and should absolutely preclude operative measures. The medical treatment includes open-air life, and a liberal, easily digested diet. Tonics should be administered, iron, arsenic, cod liver oil, and malt.

The surgical removal of the appendix is always indicated in the primary cases of the disease, also in cases where the systemic lesions are latent and inactive. The arguments against operation are: (1) That usually the appendix is not the only tuberculous portion of the intestinal tract, (2) the irritation of the anæsthetic is liable to cause a violent recrudescence of quiescent pulmonary areas. Still further the fear of fæcal fistula from poor reparative power deters many men from operating. However, with careful technic, fæcal fistula rarely occurs. Gas-oxygen anæsthesia reduces the pulmonary irritation to a minimum, and spinal analgesia absolutely removes it. Convalescence is established within a week, thus the hygienic treatment is but little disturbed.

CONCLUSIONS

1. Tuberculous appendicitis occurs more frequently than is generally recognized. About 0.5 per cent. of all appendices removed surgically are tuberculous.

2. There are three forms of the disease, miliary, ulcerative, and hyperplastic. The lesion may be primary or secondary to tuberculosis elsewhere in the body. The primary form is extremely rare.

3. The diagnosis rests upon the demonstration of an afternoon temperature, progressive weight loss, evening sweats and pain and tenderness in the right lower quadrant.

4. The prognosis is unfavorable except in the very rare primary forms of the disease. It is best in the hyperplastic form.

5. The treatment is operative whenever possible. Active pulmonary lesions contra-indicate operation. There is no medical treatment of the lesion in the appendix itself. Hygienic treatment is indicated in active pulmonary conditions associated with tuberculous appendicitis.

OBSTRUCTION OF THE URETER

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As an etiological generality, the type of ureter obstruction we here discuss is mentioned vaguely or clearly in every modern text: as a clinical entity it has never received the attention it deserves. Commonly it is ignored altogether.

Detection of a secondary pyonephrosis or of a giant terminal hydronephrosis requires no particular diagnostic acumen and certainly these conditions when met are diligently enough attacked. To the master urinary mechanic, however, something more than this is desirable. Prevention of these conditions is worth vastly more than their cure, and this accomplishment is definitely and persistently associated with the recognition and early relief of ureter obstruction. Perhaps of even greater importance, from the viewpoint of the patient, is the possibility of obtaining relief from those years of suffering and ineffective intra-abdominal exploratory excursions which intervene between the time the true but hidden pathology begins and the time it reaches such vast proportions as to speak unequivocally for itself. It is with this interim that we deal. Our object is to emphasize most strongly the significance of chronic ureter obstruction as a thing of itself, to be treated with the respect its symptom-producing powers demand, to be deliberately sought in possible explanation of certain perplexing clinical pictures, and to be promptly remedied by means often quite simple but quite effective.

Effect of Obstruction.—Obstruction of the ureter may result from a variety of causes, congenital and acquired. If the obstruction is incomplete a gradual dilatation of the ureter and pelvis occurs with the eventual production of hydronephrosis, inevitable secondary pressure atrophy of the kidney, and probable secondary infection from stasis and lowered resistance. If, on the other hand, obstruction is absolute, one of two conditions results:

(*a*) Primary atrophy, intrapelvic urine pressure blocking the renal vessels at the hilum to such an extent as to prevent the influx of sufficient blood to carry on the renal function.

(*b*) Hydronephrosis, intrapelvic pressure producing the same result here, but the capsular anastomosis being so free as to allow a certain amount of blood to still reach the kidney, insufficient to maintain its function but large enough to cause the gradual pouring out of a transudate—not true urine—which slowly distends the pelvis. Of these two effects of complete blockage of the ureter the former is much the more common.

Congenital strictures may be dismissed from the present consideration. They unquestionably occur frequently and the literature has rather thoroughly canvassed them from every point of view. To claim as do Bottomley and Eisendrath that they are more common than the acquired forms or that the

latter are in most instances essentially congenital in origin is, we are convinced, a mistake, except that certain types of stenosis, as will be shown later, manifest themselves first, as would be supposed, at the points of anatomic narrowing in the ureter.

Of the acquired obstructions, several types may also be eliminated from the discussion. The stenosis resultant upon a tubercular ulceration is well known, but we are here less concerned with the ureter than we are with the excision of the kidney above. Obstruction due to lithiasis concerns only removal of the stone, though the same is not true of obstruction secondary to traumatism from a stone that has been removed or been passed. The ureter may be blocked to a greater or lesser degree by the pressure of tumors from without or within or by involvement in malignant growths, most common of which is carcinoma of the cervix uteri. Infections other than tubercular may be associated with secondary stricture and a variety of other possibilities might be enumerated.

The Earliest Stage.—In all these conditions, however, the primary consideration lies elsewhere than in the ureter itself. The clinical picture then surrounds a tuberculosis, a stone, a pelvic tumor, a pyonephrosis, or a malignant cervix, and the ureter engages attention only incidentally. It is entirely different with the cases we have in mind. Here we present a patient who obviously has none of these things, but who nevertheless has something which persistently though vaguely upsets his balance. There may be nothing more than a chronic backache or there may be severe attacks of abdominal pain. Bladder disturbance may be absent or conspicuous. Urinalysis may show a few pus- and blood-cells; more commonly it is negative even in cases with considerable vesical excitability. The attacks of pain, which in women are often precipitated by onset of menstruation, may, in the absence of urinary findings, so closely simulate appendix or gall-bladder disease as to lead to an ineffective operation. This is particularly true among the large number of cases which present associated gastro-intestinal disturbances.

Renal pain is commonly due to tension upon the capsule or within the pelvis or both. The essential symptomatology of ureter obstruction is interwoven with the question of pelvic tension and its clinical manifestations. Unfortunately there is nothing clear cut about the picture. At a subsequent date we will undertake to present in some detail a series of observations on the evidences of pelvic tension as measured by pain, together with a note concerning associated gastric disturbances. At the present time it is sufficient merely to state our deliberate judgment that renal pain has no characteristic differentiating it from other pain. With pelvic tension may come no pain at all (rarely) or pain of any degree of severity, of any location within the abdomen, and of any or no radiation. It may accurately imitate appendicitis, cholecystitis, gastric ulcer, lumbago, sacro-iliac disease, and several other conditions; it may be a vague and indefinite thing, sapping the nervous system and eventually branding the hapless sufferer as a

neurasthenic. In reference to gastro-intestinal disturbance it will be interesting to note how often it is possible to produce nausea and vomiting by increasing intrapelvic tension.

It will be seen therefore that off-hand diagnosis is here out of the question. The matter is one of nice differentiation and the condition will commonly be overlooked until it is more systematically included among the diagnostic possibilities. Along with cholecystitis and chronic appendicitis as causes of intra-abdominal disorders and of lumbago and sacro-iliac disease as causes of lumbar pain, we should begin to think also of ureter obstruction. When this is done we shall have made a long step. Generally a critical analysis of the case will then at least suggest the necessity of cystoscopic exclusion of the urinary system and thereupon the picture at once becomes clear.

The bladder appearance generally (in our experience) is entirely normal. The ureteral orifices rarely suggest anything in the early stage (and it is this stage with which we are chiefly concerned). Even a small ureteral catheter may glide up to the pelvis without meeting obstruction, and if a further test is not made with a larger catheter there may be no suspicion of narrowing until a few hours later when the patient has a severe reaction due to occlusion of the ureter at the site of stricture from the trauma of catheterization. This occlusion may even occur at once, as we have often observed, and the catheter which a moment or two before passed easily to the pelvis can no longer be made to traverse the ureter. Furthermore, the patient will not fail to have a characteristic attack within the ensuing few hours. This withdrawal and subsequent reintroduction of the catheter in a suspected ureter may prove a valuable diagnostic point.

If, as has been our experience also on several occasions, one has found it necessary soon afterward (the next day) to catheterize again, he will appreciate the situation still further. The orifices are now puffed up and the ureteral mucosæ so tightly swollen that not even the smallest bougie can be passed.

In a majority of cases, however, the stricture is directly discoverable at the first examination and an unusually severe reaction is not necessary to reveal it. The catheter is suddenly halted. The usual manipulations will quickly determine that the obstruction is not due to a simple bend or valve-like fold. We then realize that in spite of normal urine seen coming in fairly normal spurts from the ureter, we have met a definite obstruction. The passage of a waxed catheter up to the point of obstruction will determine (by absence of scratches) that it is not due to stone. If we can slip by with a small catheter, we measure the pelvis and compare its size with that of its fellow, for we are expecting a dilatation. In addition we apply Kelly's pain identification test by overdistention (using the gravity method always). We regard this test as of the utmost value and up to this time have never yet failed to have the patient, with violence (but correctly, as the issue proved), either declare positively that we were off the track or else had hit the trouble squarely on the head.

If the catheter will not pass, we can still, with prospect of success, attempt measurement and overdistention with the hope that the fluid will pass where the catheter will not. On the same principle we may have pyelograms made and graphically outline the contour of the affected ureter and pelvis.

Dilatation Not Always Present.—As stated above, we expect dilatation. It does not follow that we always find it, or that it is an essential part of the diagnostic data. On the contrary, we would lay great emphasis upon the fact that *in its early stages stricture may cause definite symptoms (from pelvic tension) without any dilatation whatever or any prevention of a steady downflow of urine.* Later, dilatation, first of the ureter and then of the pelvis, inevitably occurs and progresses. In this connection we furthermore wish to note that dilatation in some cases, as shown in the unusual pyelograms (Figs. 5 and 6), may be a very transitory affair. When the obstruction is suddenly accentuated, as in a moving kidney or during an acute congestive swelling around a partial stricture, the pelvis may become considerably distended and within a very brief time thereafter may entirely recover its tone.

The stricture from infection is usually near the bladder, but may be near the kidney or at the point of crossing of the brim of the bony pelvis. Obstruction from other causes to be detailed may also occasionally appear elsewhere. There may be a local point of sensitiveness corresponding to the site of the stricture, and pain, during the attacks, may begin here and radiate upward to the kidney or downward to the bladder or both, as classically illustrated in one of our cases. Furthermore, the approach of the catheter tip to the strictured area may arouse an identifying exclamation from the patient.

Finally, it should be noted that stricture may not only result from infection but may be the cause of it. The lowered resistance incident to urinary stasis often invites bacterial invasion. If attention is directed only to the infection and the obstructive element is overlooked, treatment, however diligent, will fail. In such a case the ureter should be regarded as the drainage tube of a pus pocket which has become partly occluded. Introduction of antiseptics into the pocket (lavage of pelves) will produce temporary improvement but recurrence will be prompt as long as the occluding element remains. When to lavage is added dilatation of the stricture, opening the ureter widely and insuring free and constant drainage, the patient will usually get well.

Etiological Factors.—A consideration of the etiology at this time, with some reference to actual observations, will further clarify the situation. It is necessary to recall that we are limiting the discussion to a particular type of obstruction and excluding all others. The etiological factors associated with this particular type are, in our experience, as follows:

1. *Systemic Infection of the Ureteral Wall from Distant Foci, such as Diseased Tonsils, Sinuses, Teeth, or Digestive Tract.*—Credit for the recog-

nition of this most important factor should go largely to Hunner who, however, in our judgment, emphasizes it unduly at the expense of other types of equal importance. It is apparently a far cry from the tonsil to the ureter, but under the leadership of Rosenow, whether we follow him all the way or not, we are coming to learn something of the strange selective affinities of bacteria. We have under observation at this time a most interesting case of this sort. Symptomatology consisted of intense backache, weakness, and nervousness, with previous history of tonsillitis and mastoid disease, both requiring operation. Urinalysis was negative. A dense stricture was discovered in the right ureter. Pain identification test was absolute. Pyelography (Fig. 1) showed the right pelvis small but twice the size of its fellow (relative dilatation) and somewhat deformed. The stricture, after some difficulty, was widely dilated. It is too early yet to judge the results, particularly as the situation is complicated by a degree of mobility of the right kidney which may or may not be controlled by an abdominal supporter which has just been fitted.

In another almost identical instance we have by the same means succeeded in completely transforming a young woman who had undergone an unsuccessful operation for appendicitis and spent many years in the hands of physicians unable to relieve her of pain. This was one of the most clear-cut cases in our series and yet the pelvis of the affected (right) side presented no dilatation whatsoever (Fig. 2).

2. *Anatomic Narrowing.*—Three points of anatomic narrowing exist in the ureter: Near the pelvis of the kidney, near the bladder, and at the brim of the bony pelvis. In certain cases, several of which have come under our observation (all in women), there is apparently an accentuation of these anatomic narrowings which, under the influence of acute congestion (menstruation), may produce definite pain and other urinary symptoms. At all events in these cases we have not been able to identify any other etiologic factor and the narrowings have not presented the characteristics of true strictures. The trouble is practically always near the bladder.

3. *Appendicitis.*—We refer here not to systemic conduction of infection from appendix to ureter but to direct involvement by contiguity. The proximity of appendix to ureter at the pelvic brim and in retrocæcal positions should be recalled. Recently we have been particularly impressed with this consideration. The patient was a young boy with a gangrenous appendicitis. A McBurney incision was made and the appendix removed. Before this was done, however, the operator had stripped up several inches of the ureter which was thick, œdematous, and so extensively involved in the neighboring inflammation that it was at first mistaken for the adherent appendix. The development of a stricture in such a ureter would not be unexpected. The well-known coincidence of urinary findings with retrocæcal appendicitis teaches the same lesson. In one of our cases of this group the patient underwent a second operation for cholecystitis and adhesions which did not exist, her backache and pain being finally and permanently relieved by dilatation of a stricture in the right ureter.

FIG. 1.—Stricture in right ureter complicated by mobility of kidney. Note relative dilatation (and descent) of right pelvis which by measurement was found to have twice the capacity of its fellow of the opposite side.

FIG. 2.—Stricture in right ureter with marked symptoms *but no dilatation of affected pelvis* either by actual measurement or pyelographic evidence. Complete relief after stretching of ureter.

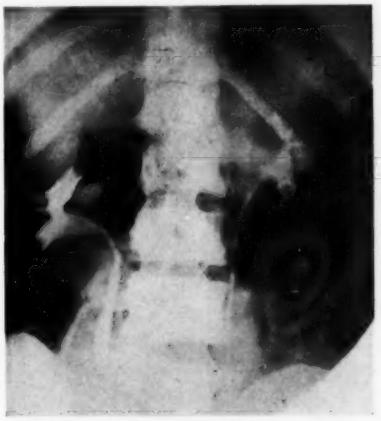

FIG. 3.—Persistent unilateral pyelitis not relieved until obstruction in right ureter due to mobility of kidney was corrected by high nephropexy. Note torsion of kidney, pelvis occupying a nearly horizontal instead of vertical position.

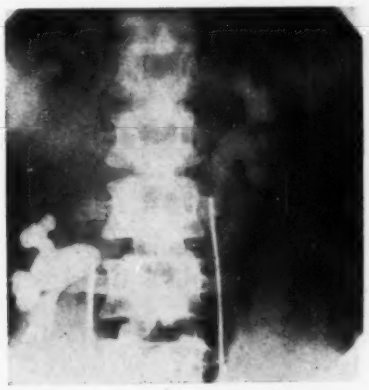

FIG. 4.—Obstruction of ureter due to prolapse of kidney, with which is probably also associated either an aberrant blood-vessel or a constricting fascial band. Note characteristic dilatation of right pelvis, with acute angular ureteropelvic junction.

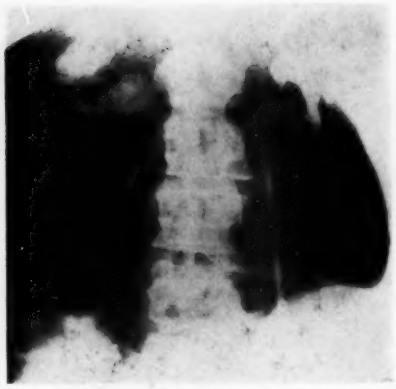

FIG. 5.—Extensive hydronephrosis with sharp kinking of right ureter, occurring in patient with infected mobile kidney. Degree of dilatation sufficient to demand nephrectomy.

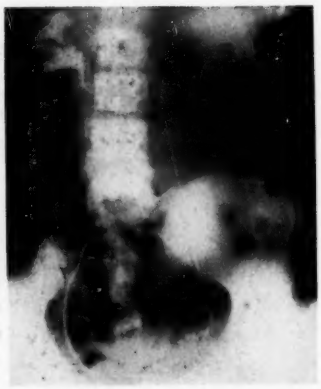

FIG. 6.—Same case as Fig. 5, taken short time later and exhibiting straight course of ureters and pelves of normal size. The fortunate accident (omission of leaded catheters in first plate) which secured this remarkable pair of pictures produces a striking lesson in the ability of an acutely dilated pelvis to recover its tone.

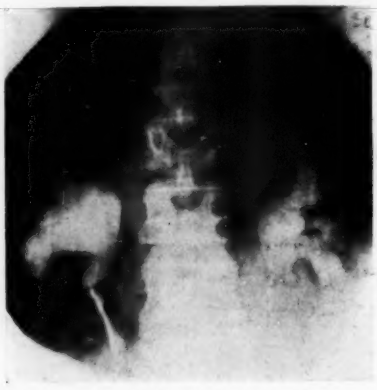

FIG. 7.—Bilateral hydronephrosis (without infection) due to kinking of both ureters near bladder following total hysterectomy.

FIG. 8.—Stricture in rudimentary third ureter. Dilatation of this stricture relieved backache for which patient had undergone a number of ineffective operations.

FIG. 9.—Large hydronephrosis with no other apparent etiology than embarrassment of intravesical portion of ureter by enormously hypertrophied bladder musculature.

FIG. 10.—Same as Fig. 9, showing straight course of ureters which were unobstructed except at bladder wall. After overcoming this obstruction No. 11 Garceau catheters were easily passed to pelves. Plate taken with catheters of this size in place, each containing a small leaded bougie.

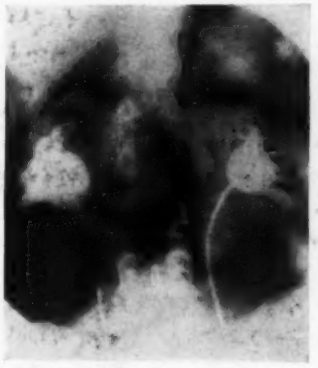

FIG. 11.—Bilateral dilatation of pelves due to obstruction of intravesical portion of ureter by hypertrophied bladder musculature.

4. *Syphilis.*—Undoubtedly Kelly is right in his assertion that syphilis may definitely cause stricture of the ureter and that the affection is probably not nearly so rare as supposed. We have had no experience with this type but expect that a more systematic observation in this direction will in all likelihood be productive.

5. *Mobility of Kidney.*—Here we refer simply to obstruction, since this condition does not enter into the etiology of stricture. Its coincidental bearing on the present discussion, however, is so considerable that it is included for purposes of completeness. In one case (Fig. 3) persistence of infection of the right renal pelvis, in spite of systematic lavage, suggested stone or stricture, but notwithstanding diligent search no stone or stricture was demonstrable. We succeeded, however, in finding what was tantamount to the same thing—an obstruction due to torsion of the ureter from descensus of the kidney. When this was corrected by high nephropexy the patient recovered. Fig. 4 classically shows another case of obstruction and resulting dilatation and infection of the kidney due to descensus, with which is probably also associated either a fascial band or an aberrant blood-vessel; this patient refused operation. Finally, we wish to note again the significance of Figs. 5 and 6. Here displacement of the kidney had resulted in such a high grade of hydronephrosis that nephrectomy would have been justified if the second plate had not been made a short time later, showing the complete restoration of the tone of the pelvis after the obstruction had been automatically relieved. Fixation of this kidney would also probably have relieved the right-sided pyelitis which is still present in spite of thorough lavage.

It must not be understood that we are even remotely advocating systematic surgical attacks on mobile kidneys. The ordinary moving kidney is of no significance and the persistent teaching of recent years has thoroughly instilled this into the professional mind. On the whole, this is work well done, but there is danger that the pendulum will swing too far. Indiscriminate contempt for renal mobility is a serious error. In a certain minority of cases the condition is definitely pathological, and, when these cases are carefully sifted out with the cystoscope and the other means at our disposal, operation is not only justified but demanded.

6. *Broad Ligament Inflammation.*—The ureter may be directly involved as in appendicitis or it may be secondarily caught and compressed in the dense fibroid mass which sometimes ensues when an acute parametrial infection subsides. This point is also brought out by Clark and Keene in an excellent article on the relation of the urinary system to the female pelvic organs. Frequent observations during our pelvic operations commend this factor to serious consideration.

7. *Stone.*—It should be noted in passing that the traumatism produced by a stone which has been expelled or removed may later on itself assume primary importance as a cause of obstruction due either to cicatricial contraction or to infection at a point of lowered resistance.

8. *Operations.*—Repair of the pelvic floor following ordinary hysterec-

tomy may involve the ureter either by displacement and distortion or by definite involvement in scar tissue. We have noted several cases of this type but refer to only two which were quite striking. Six months previously in another city a fibroid tumor of the uterus was removed from one of these patients. Two months after the operation she began for the first time in her life to have urinary disturbance. When she came to us she was nearly bedridden with frequent urination and pain which started near her bladder and radiated upward to her abdomen and back. Urinalysis was negative. Bladder appearance was insignificant. The left ureter was clear. On the right side a tight obstruction was met. As soon as the catheter tip reached this point the patient complained of the characteristic pain near her bladder and the pelvic distention test proved an indisputable further identification. A waxed catheter showed no scratches. Specimens from both kidneys were normal. The capacity of both pelves was small. The stricture was widely dilated and the improvement in the patient was spectacular to a degree. In the other case total hysterectomy had been done a few years previously. The patient now came to the hospital with pain in the right side and an easily palpable tumor extending downward from the right costal margin. The cystoscope disclosed bilateral ureteral kinks a short distance above the bladder, producing definite obstruction with hydronephrosis on both sides, but with absolutely no evidence of infection. Pyelograms showed the pelves as illustrated in Fig. 7.

9. *Pregnancy.*—Obstruction of the ureter may occur from pressure of the pregnant uterus resulting in temporary low grades of hydronephrosis. The well-known pyelitis of pregnancy is doubtless coincident upon this condition. In addition the lower end of the ureter may suffer from the trauma of labor and the result may be a stricture or an outright necrosis with ureterovaginal fistula.

10. *Renal Infection.*—In the opinion of Hunner, stricture is the primary condition when it is associated with infection in the pelvis or kidney. Furniss takes the opposite view and declares that many hæmatogenous infections of the kidney persist as pyelitis, ureteritis or cystitis with consequent contraction and stricture so far as the ureter is concerned. Kelly appears to agree with Furniss and adds, "Although a secondary development the strictures in such cases assume primary importance, for the infection cannot be relieved so long as they exist." Our experience would lead us to agree with both views in the sense that we believe some strictures to be primary and the cause of subsequent infection of the kidney; and some infections of the kidney to be primary and the cause of subsequent stricture of the ureter. This is the " descending type " according to Furniss, and the colon bacillus is the chief offender. There is also an " ascending type " with which the gonococcus may be associated, according to Garceau. Both Furniss and Hunner quote Kelly as authority for the statement that gonorrhœal ureteritis is very rare and yet Kelly in his latest publication declares: " Gonorrhœal infection is a common cause; many cases being on record."

11. *Anomalies.*—Unilateral reduplication of the ureter is fairly common. The supernumerary ureter and its pelvis are generally rudimentary in size. Either infection or stricture or both are extremely likely to occur here. In one of our cases (Fig. 8) the patient had undergone three abdominal operations, the last of which was partial colectomy. The right-sided pain which was one of her outstanding symptoms persisted in spite of all this. We determined the presence of a tight third ureter with a low-grade pyelitis in its pelvis. Dilatation of this ureter and irrigation of the pelvis relieved her and she went more than a year without pain. Subsequently she began to have trouble again and cystoscopic examination showed a definite recurrence of the stricture which required additional dilatation together with enlargement of the orifice with ureteral scissors.

12. *Hypertrophy of Bladder.*—Finally, we wish to note an obstructive factor which may be present either with or without the association of what appears to be a type of paresis of the renal pelvis. A very cursory and incomplete inspection of the literature furnished us with no references to bladder hypertrophy as a cause of ureteral obstruction. In several cases, however, we have been highly impressed with the importance of this condition. In one of these the patient was about to undergo operation for cholecystectomy when an inquisitive cystoscopist extracted the supposed hydrops of the gall-bladder through a ureteral catheter. Constant straining to overcome a mild grade of retention due to cystocele had produced in this patient an extensive muscular hypertrophy, the bladder wall being honey-combed with trabeculations which could not be obliterated by water distention. A considerable hydronephrosis was present on the right side (Fig. 9) and a lesser degree of dilatation (by measurement) on the left. The ureters were straight and unobstructed (Fig. 10) except where gripped by the contracting bladder. Apparently the sole condition here was insufficient expulsive force in the pelves to overcome the resistance produced by the engagement of the vesical portion of the ureter in the hypertrophied musculature.

It must be explained that we do not refer to the very common and well recognized types of hydronephrosis due to urethral, prostatic, or other obstructions in which the ureteral orifices and ureters become widely dilated so that the bladder becomes practically continuous with the pelvis. The type we here present is an entirely different affair. *The ureteral orifices are not dilated but contracted, an essential point in the consideration.* Responding to the demands made upon it, the bladder musculature has undergone great hypertrophy which has involved the region of the intravesical portion of the ureter as well as the remainder of the bladder. The termination of the ureter then rests among accentuated contractile elements which may seriously embarrass it. We have beautifully illustrated this in a recent case. With the bladder distended to its utmost capacity and the bands flattened out, large catheters (Garceau No. 11) can be easily passed to both pelves. With the bladder less distended, however, and the trabeculations standing out boldly, obstructions can be felt in the intravesical portion of both ureters

and at this time even small catheters are with much difficulty engaged in the orifices. The effect on the patient is well illustrated in Fig. 11.

Treatment of Obstruction.—The clinical picture here presented represents the early " benign " stage, the underlying pathology of which is a ureteral obstruction that is only partial as yet; that does not prevent urine from passing steadily into the bladder; that, however, maintains a certain grade of resistance resulting in intrapelvic tension sufficient to occasion chronic discomfort; that in the presence of acute congestion (as from menstruation, superimposed infection, etc.) may suddenly become much accentuated, precipitating severe colics from transient hydronephrosis, the latter sometimes being accompanied by gastro-intestinal and systemic disturbance. The essential clinical signs, therefore, are chronic pain in the back or elsewhere and attacks of colic with either or both of which may or may not be associated digestive upsets, bladder disturbance, and pathologic elements in the urine. The remainder of the diagnostic data is elicited by the cystoscope, as explained.

It is in this benign stage that diagnosis should be made and treatment instituted. If this is not done the pathology gradually changes and the symptomatology along with it. The obstruction becomes more and more serious and the intrapelvic tension greater and greater. Eventually definite hydronephrosis occurs, the kidney parenchyma suffers from pressure, and the devitalized organ becomes an easy prey for bacterial visitants. When this occurs the opportunity for conservatism has generally passed. The condition may be discovered, however, at any point between these initial and terminal stages. The clinical symptoms and cystoscopic disclosures will then be modified according to the extent to which the condition has progressed up to that time.

The individual case will suggest the proper treatment. If the condition is unilateral and serious involvement of the renal parenchyma has ensued from infection or hydronephrosis, nephrectomy will probably be required. Obstruction dependent upon mobility of the kidney will necessitate fixation and simultaneous division of the fascial bands or aberrant vessels generally responsible for the real trouble; of these two procedures the latter is considerably more important. Plastic operations on the pelvis and upper ureter may be done in other cases. All these measures are the more radical. In the early strictures, before irreparable damage has been done to the kidney—that is to say in the stage which has concerned us chiefly in this review—more conservative remedies are available. The simplest, and in the majority of cases the best and most effective, measure is dilatation of the stricture from a vesical approach by means of bougies, dilating catheters, or metal instruments.

If this is ineffective or inapplicable, the pelvis or ureter may be opened above the stricture and retrograde dilatation done. Finally, if the stricture is particularly dense and the involved segment is of considerable length, the ureter may be divided and the proximal end reimplanted in the bladder.

In our experience thus far, dilatation from the vesical side has been all that was necessary, but we do not fail to bear constantly in mind the propensity of dilated strictures to re-contract. We use the Kelly, the Braasch, or the Buerger type of cystoscope, according to circumstances. Our experience with wax bulbs has not been as satisfactory as Hunner's, since in our hands the bulb often yields before the stricture; this may be more the fault of our wax than of the method. The Garceau type of catheter and the solid dilating bougie with filiform end have been our instruments of choice. The further details of the process are of interest chiefly to the cystoscopist.

SUMMARY

1. For clinical purposes obstruction of the ureter may be separated into two classes: (*a*) The ureteral condition is a mere incidental consideration, the dominating pathology lying elsewhere, within or without the urinary tract. (*b*) The obstruction itself constitutes the essential pathology. In the former, treatment must be directed elsewhere than to the ureter; in the latter, relief of the ureteral obstruction will cure the patient if undertaken early enough.

2. The second type, which is that chiefly concerned in this review, is associated etiologically with a variety of commonplace conditions and is of far greater incidence than even imagined by the ordinary observer. The most frequent etiologic factors determinable are: (*a*) Involvement of the ureter in some distant focal infection, such as tonsillitis; (*b*) excessive mobility of the kidney associated with fascial bands or aberrant blood-vessels; (*c*) renal infection with concurrent or subsequent inclusion of the ureter; (*d*) distortions of the ureter following pelvic operations; (*e*) local traumatism or infection associated with passing calculi; (*f*) cicatricial residues surrounding the ureter following appendicitis and broad ligament inflammation; (*g*) hypertrophy of the bladder. In a certain percentage of cases the etiology will remain questionable or entirely undiscovered.

3. Symptomatology is primarily associated with pelvic tension, a condition producing pain of so variable a character as to promote the utmost diagnostic confusion. Chronic digestive disturbances may or may not be present. The urine is as often negative as not.

4. The conditions most often simulated are chronic appendicitis, cholecystitis, lumbago, sacro-iliac disease, post-operative adhesions, and neurasthenia.

5. In the presence of indefinite symptomatology, ureteral obstruction must hereafter be included among the diagnostic possibilities and must be excluded before we can feel justified in removing a "chronic appendix" or dismissing the patient as a "chronic neurasthenic."

6. The diagnosis is made with the cystoscope and the pyelogram, though it must be constantly borne in mind that symptom-producing obstruction may exist without hydronephrosis.

7. Treatment consists of relief of the obstruction by such means as may be required in the given case.

ON GASTRIC AND DUODENAL ULCERS FROM A SURGICAL POINT OF VIEW*

By Abraham Troell, M.D.
of Stockholm, Sweden

I. FREQUENCY; LOCALIZATION; SYMPTOMATOLOGICAL AND DIAGNOSTICAL CONDITIONS

Among 234 cases of chronic ulcers operated on in the Seraphim Hospital, in Stockholm, during the period 1907–1914, 76 per cent. were localized to the stomach and 24 per cent. to the duodenum. Of the former, 36 per cent. occurred in men and 74 per cent. in women; of the latter, 67 per cent. in men and 33 per cent. in women. Of all the male cases, 63 per cent. had gastric ulcers and 37 per cent. duodenal ulcers; of the female ones, 86 per cent. and 14 per cent. respectively.

More than half of all the ulcers (or of the sequelæ of ulcers) in the stomach were extrapyloric, *i.e.*, situated proximally to the canalis egestorius, while the total number of both gastric and duodenal cases with juxtapyloric localization, *i.e.*, in or in the vicinity of the pylorus, by almost 10 per cent. exceeded the frequency of extrapyloric stomach ulcers.

Multiple ulcers were traced in about 5 per cent. of all the cases.

The time when the ulcer pains appeared gave no important, or for the diagnosis definite, distinction between gastric ulcers and duodenal ones; among the cases with late-appearing pain there were a considerable number—about 50 per cent.—of gastric ulcers, while among the cases with early-appearing pain were not a few duodenal ulcers. Pains commencing soon after meals seemed to indicate an extrapyloric gastric ulcer, and late-occurring pains gave preponderate reasons for suspecting a juxtapyloric gastric or duodenal ulcer. Those patients who complained of pains appearing tardily after meal, nightly pains, and hunger pains, in far more cases—about 66 per cent.—had juxtapyloric (gastric or duodenal) ulcer than extrapyloric gastric ulcer. Even patients with pains occurring soon after meals had, however, to a great extent—in close upon 50 per cent.—juxtapyloric ulcer, on one side or other of the pylorus. Those patients with extrapyloric gastric ulcer who had pains later than two hours after taking food, all had residue. The total acidity in extrapyloric gastric ulcer with hunger pains, and in juxtapyloric duodenal ulcer with pains within an hour after food, was, on the whole, relatively high. (Throughout, the figures for the total acidity were obviously low in all patients with ulcer, though higher in duodenal than stomach cases.

* This paper is a very brief abstract of a more extensive one, the contents of which was read in the Swedish Medical Society on April 18, 1916 ("Svenska läkaiesällskapets handlingar," xxxxii, p. 1343–1480).

Hyp- and anacidity occurred both in duodenal and especially in gastric ulcers. As an average, the acidity was lower for cases with residue than for those without, 40 and 53 respectively. Disagreements and variations in the results obtained by different examinations concerning the motility of the stomach were not uncommon. They confirm the known fact that X-ray examination is, as a rule, a more satisfactory method for proving slighter disturbances of gastric motility than either the bilberry or prune test at ordinary test-meal examination. They occur at pylorospasm, but also in a number of cases in a manner which makes one believe that a stomach in which an organic stenosis has begun to give great demands on its motoric power, in spite of the compensatory hypertrophy of its muscular coat, cannot always overcome the obstruction—at a still narrower stenosis it can never overcome it satisfactorily.)

There are—at least for a time—absolutely painless ulcers; all such cases in this material have had a localization to the frontal wall of the organ in question, but both juxtapylorically and extrapylorically.

Of those cases where taking food has caused alleviation of pain, two-thirds have had ulcer of the stomach (no less than 11 of them have had extrapyloric ulcer). For 15 per cent. of all cases it is stated that spontaneous or induced vomiting has caused alleviation of pain.

The connection between evacuation of the bowels and pain appears in some cases to be that pains are caused by violent traction upon the adhesions to the posterior peritoneum parietale (proceeding from ulcer adjacent to intestines, especially to colon transversum), a straining which is induced by the accumulation and the aggravated difficulty of passing hard fæces through the large intestine.

Diarrhœa appeared, periodically and alternating with constipation, in some ulcer cases (22 ulcera ventriculi and 5 ulcera duodeni).

At times it is impossible by palpation of the stomach in the laparotomy wound to absolutely decide whether there is any ulcer or not. Various places in the stomach and duodenum offer various possibilities for the operator to correctly interpret an eventual pathological change. There are good reasons to claim that a palpable small callosity in or quite close to the pyloric ring does not, as a rule, imply an open ulcer, while a similar find—a circumscribed thickening of the wall without palpable crater—in parts more distant from the pylorus often proves in the removed specimen an ulcer that sometimes penetrates to a good depth.

There is good reason for retaining the chemical denomination "ulcer tumor" as the term corresponding to a certain pathologic-anatomical ulcer type, the slowly perforating, adjacent-organs-attacking ulcer.

X-ray examination has been found very important, chiefly as it is able to discover ulcers in the lesser curvature ("niche"). The niche-symptom, in respect to indication, is as valuable as the presence of pyloric obstruction, continuous residue in the stomach, the impossibility of

excluding cancer, and more valuable than pain caused by perigastritis, repeated hæmatemeses or melæna, in spite of due internal treatment. It is, however, necessary to have in mind other possibilities than ulcer when interpreting pouch-like excavations in the gastric wall. The Röntgen plate may show such that are not of niche nature, this, for instance, depending on perigastric adhesions.

It is not in every case, though in very many, that the Röntgen rays can definitely determine whether an anatomical hour-glass stomach be present or not. (The frequency of hour-glass stomachs in the ulcer cases under consideration amounts to fully 10 per cent.; the purely clinical symptoms do not, as a rule, deviate in any characteristic manner from those of other chronic ulcers of the stomach.) "Mixed stomach" (*i.e.*, hour-glass form on a partly organic, partly spastic basis) occurs only exceptionally.

Heliciform deformation of the stomach may perhaps, for a part, be caused by the ligation of the gastric artery (without ulcer excision). Röntgenologically in such deformation there has at times been observed a filling defect in the bismuth shadow of the horizontal part of the stomach ("sinus" and "canalis"), a backward bending of the pylorus region, or a considerably increased breadth of the stomach cavity (as in organic pylorus stenosis).

As to the Röntgen diagnosis of duodenal ulcer, it may be stated that such signs as tenderness of the duodenum niche, the presence of occluded gas high up in the duodenum vertex (critically computed), a constant incisura of the duodenal wall, a permanent contraction of the entire bulbus duodeni, a very rapid passage of food through the duodenum (hyperperistalsis, or antiperistalsis), have never proved diagnostically misleading. Less reliable are such symptoms as a localization of the pylorus more to the right, a distention of duodenum, or a longer remaining of food than usual in the duodenum (residue). On the whole, it may be stated that, as regards diagnosing duodenal ulcer, after due consideration of the radiological findings, they form a valuable plus to the characteristics of this disease, faint and difficult to interpret as they oftentimes are.

II. OPERATIONS AND OPERATIVE RESULTS; LATE INVESTIGATIONS (CLINICAL AND RADIOLOGICAL)

A comparison between the operations for ulcer in the Seraphim Hospital before 1907 and after that year proves that palliative operations during the latter period have to a considerable extent been superseded by more radical methods. Thus, previous to 1907 pyloroplasty was carried out in more than 4 per cent. of the cases, while after 1907 in scarcely ½ per cent. The figures for the frequency of gastro-enterostomy were 60 per cent. and 44 per cent. respectively. The proportion of 6 per cent.

and ½ per cent. respectively for entero-anastomosis indicates that anterior gastro-enterostomy has been substituted more and more by posterior gastro-enterostomy. A quite corresponding increase is stated concerning the radical ulcer operations. In the first series excision (segmentary resection with or without gastro-enterostomy) had been made in scarcely 5 per cent. of all the cases; in the second series in 10 per cent. Resection (pylorectomy with gastro-enterostomy) had increased from about 5 to 26 per cent.

Primary mortality from operations shows a decline from 8.5 per cent. to 6 per cent. during these periods for the entire series operated on, from 4.5 per cent to scarcely 2 per cent. for the gastro-enterostomies, and from 20 per cent. to 8 per cent. for the resections (pylorectomies) with gastro-enterostomy; for ulcer excision (segmentary resection) without gastro-enterostomy the mortality is remarkably high (67 per cent. and 33 per cent. respectively), for ulcer excision (segmentary resection) with gastro-enterostomy very low (0 per cent.). The cause of death after ulcer excision (segmentary resection) and after exclusio pylori (Doyen's and Eiselberg's method)—of each three cases—was invariably peritonitis; three of the others died of pulmonary embolism.

The results of the after-investigations (undertaken one to nine years after operation—12 per cent. of the patients did not present themselves for these examinations) show that of the entire number of patients still alive 70 per cent. have fully recovered or improved, while 12 per cent. had to submit to a new operation, and 3½ per cent. had died of gastric diseases. The corresponding figures for the total conservative operations are 66, 14, and 3 per cent. respectively, and for all the radical operations 76, 8, and 4.5 per cent. respectively. Calculated only with regard to the two usual forms of operations, gastro-enterostomy and resection (pylorectomy) and gastro-enterostomy, the figures obtained are 68, 12, 2 per cent. and 83, 5, 2 per cent. respectively for those patients who survived any length of time after their operation. Of the total number of patients submitted to gastro-enterostomy, 66 per cent. recovered or improved, while those with resection (pylorectomy) and gastro-enterostomy performed recovered or improved in 77 per cent. Poor remote results, *i.e.*, the recurrence of symptoms subsequent to an ulcus operation in many cases certainly depends to a considerable degree on the surgeon's neglecting, after each operation for ulcer, to give dietetic and other prescriptions suitable for ulcer.

If the remote results be considered by taking the localization and nature of the special changes as a starting-point, a very good result may be proved (*i.e.*, recovery or improvement) as following resection (pylorectomy) and gastro-enterostomy and simple gastro-enterostomy for ulcus ventriculus extrapyloricum in 83 per cent., respectively 76 per cent. of the surviving patients; primary mortality 0 per cent., respiration 0 per cent. Ulcus ventriculus juxtapyloricum in 88.5 per cent., respiration

81 per cent. of the surviving patients; primary mortality 10 per cent., respiration 6 per cent. Pyloric obstruction in 83 per cent., respiration 65 per cent. of the surviving patients; primary mortality 8 per cent., respiration 0 per cent. Ulcus duodeni in 90.5 per cent., respiration 55.5 per cent. of the surviving patients; primary mortality 8 per cent., respiration 0 per cent. All cases operated on, 87 per cent., respiration 68 per cent. of the surviving patients; primary mortality 6.5 per cent., respiration 2 per cent.

The superiority of resection (pylorectomy) + gastro-enterostomy to simple gastro-enterostomy is consequently manifest for all localizations of ulcerous changes; satisfactory remote results having been obtained for more than four-fifths of the resection cases surviving, but, as a rule, for scarcely three-fourths of those with only gastro-enterostomy performed; this without any far too important increase in the immediate risks of the operation engendered by radical measures. Necessary subsequent operations have occurred far oftener after gastro-enterostomy than after radical operations, proportionally about 2 to 1. Death in cancer has ensued in 2 to 3 per cent. of all the ulcer cases. With our present knowledge, it is impossible to state, even approximately, how often a gastric ulcer may undergo malignant degeneration. Concerning the question of resection or gastro-enterostomy to be claimed as the normal method for ulcus, the problem of ulcus carcinomatosum cannot as yet be of any great importance, except in so far as the knowledge that it is, in operations, impossible by eye and hand to absolutely determine, in any case, between cancer and ulcus, may be an incentive—in otherwise favorable circumstances—to remove every extirpable ulcer or sequela of ulcer seen in these laparotomies; the gross pathological picture in vivo oftentimes being very misleading, according to experience gained. In laparotomies on account of ulcer the surgeon should strive to decide at as early a stage as possible, whether extirpation (*i.e.*, resection, excision) should be undertaken or not; should it not be done, the lysis of adhesions, especially in suspected regions, must be undertaken with a certain degree of caution, and with due care that penetrating ulcers (whence perforation as a speedy consequence of the operation may threaten) may be passed over to a minimal degree.

Among other abdominal complications following on operations, circulus vitiosus and ulcus pepticum jejuni are most specially to be taken into consideration. Also, from the ulcer series at hand, it appears that concerning the development of circulus vitiosus, among other causes too great a length of afferent duodenal loop in posterior gastro-enterostomy plays a certain rôle.

For diagnosing an ulcus pepticum jejuni, X-ray examination may be a good help (bismuth-shadow of the pouch that may be formed by the ulcer penetrating towards colon; see Fig. 1). On the occurrence of ulcus pepticum jejuni the use of uninterrupted silk as suture of the

FIG. 1.—Resection (pylorectomy) and gastro-enterostomy (Billroth method, No. 2) performed in July, 1911. Excellent condition for the next three years, then symptoms of ulcus pepticum gastrojejunalis. X-ray examination in February, 1916, which showed, among other things, residue in the stomach and immediately below that shadow a bismuth-filling (×) of the size of a big walnut, which, according to the operative findings, corresponded exactly to a big pouch formed by a gastrojejunal peptic ulcer penetrating toward the colon. This ulcer was resected, an atypical anastomosis was done, and the patient recovered.

FIG. 2.—Resection (pylorectomy) and gastro-enterostomy (Billroth method, No. 2) performed in October, 1912. Only slight improvement, after three years a number of symptoms persisting. X-ray examination in January, 1916, showed, among other things, a four-hour residue in the stomach between the gastro-enterostomy opening and the pylorus (×).

deeper layers of the gastric wall may be of significance. Among the more unusual postoperative local complications there may be taken under consideration not only the incarceration of small intestines in bursa omentalis (to avoid which it is of importance to regularly sew the margins of the mesocolon opening to stomach or intestines, round the place of the gastro-enterostomy), but also there is to mention the chronic, more or less complete, volvulus of the stomach, eventually caused by the strings and adhesions, and not necessarily accompanied by symptoms of ileus.

The X-ray examination gives valuable information for the interpretation of the postoperative stomach physiology; 64 patients of the ulcer series in question have been submitted to it. As to that point the results of experiments on animals cannot be transferred to clinical conditions without further ado. X-ray examination made some lengthy time after gastro-enterostomy on ulcer patients proves that the food passes exclusively through the anastomosis, not only in pyloric obstruction, but also in most of the cases with permeable pylorus. Quite exceptionally the pylorus takes some part, or to a greater extent than the anastomosis, in allowing the food to pass, or even the entire contents of the stomach go through the pylorus. To what degree the localization of the new opening plays any rôle for the deliverance of the gastric contents means little, on the whole, so long as it is only a question of such slight obstruction of motility as a bismuth residue after four hours, which, in itself, is of no importance as regards clinical symptoms. Location of the gastro-enterostomy toward the pylorus appears, however, to offer the best guarantee for a satisfactory function thereof, even if the position of the new opening does not mean the only factor for determining the way of passage for the gastric contents. With regard to the relation between the functional power of the gastro-enterostomy and the ulcer troubles of the patients, the experience in the Seraphim Hospital proves that the group with food passage only through the anastomosis for the most part consists of completely, or almost completely, restored cases (when this does not happen, a special reason is, as a rule, discernible). In those patients where the pylorus, in spite of the gastro-enterostomy, continues, more or less, to deliver gastric contents there remain slighter or more severe clinical troubles, not seldom of neurotic kind. X-ray examination after resection (pylorectomy) and gastro-enterostomy proves on the one side that "paradoxal residue" is not so very rare, and on the other one that a small residue even at a lengthy period after the operation may occur without itself being of any clinical importance. With regard to the possibility of pouch formation in the stomach distally to the spot where gastro-enterostomy was performed (see Fig. 2), it is desirable to make the gastro-enterostomy as far to the right as possible (near the place of resection). The risk of pouch formation—the clinical rôle of which cannot be denied—is also present in exclusio

pylori by circular constriction through an aponeurotic strip, a silk thread, etc., and vindicates the demand that, when this operation can be considered worth trying, the gastro-enterostomy should be established near the pylorus. The uncertainty in the results of these conservative exclusion methods compared to the experiences above, gained from simple gastro-enterostomy in cases of open pylorus, makes it very doubtful whether there are any valid reasons for their further employment. Rissler's method, perhaps, with slighter risk, gives equally effective results as operation, according to Doyen and Eiselberg. Subsequent to resection in continuity + suture end to end, there is a certain risk of secondary hour-glass formation. For radical hour-glass operations the same rules hold good principally as regards corresponding operations for other ulcer conditions, as also (where suitable deformation and motility circumstances are present) in gastro-enterostomy. Among the more complicated conservative operations gastro-enterostomy + gastro-enterostomy of the pyloric pouch has given good motoric and functional results, while lateral anastomosis between the cardiac pocket and duodenum, on the contrary, has given bad results (pouch formation).

Relaparotomy undertaken several years after gastro-enterostomy proves that the gastro-enterostomy, as a rule, has no tendency of gradual closure—not even if the pylorus at the first operation were open—unless special conditions were present (anastomosis by Murphy's button, complicating peptic gastrojejunal ulcer (?), subsequent cancer, etc.). A gastro-enterostomy may, in the course of years, cause the dissipation of a scarred pyloric obstruction. It may also, already in the course of a couple of months, induce a diminution of the volume of a dilated stomach.

The majority of the ulcer cases operated on, on subsequent examination appear to have normal total acidity, and that even when clinical troubles still persist; the degree of acidity scarcely is of decided importance for the non-appearance of improvement after an operation.

Constipation in ulcer patients is usually promptly and definitely obviated by an otherwise effective ulcer operation. This is generally also the case as regards diarrhœa occurring in ulcus. Postoperative diarrhœa seems to stand in some connection with such pancreatic changes as are characterized by the destruction of the parenchyma. They are not, as far as can be proved, attributable to a too broad gastro-enterostomy, or to a too rapid deliverance of the gastric contents to the intestine (both these conditions have been observed without diarrhœa occurring, as also the contrary conditions have been seen in operated cases with diarrhœa). Neurotic moments are probably more responsible for the appearance of diarrhœa.

There is much that speaks for constitutional, neurogenous, and spastic moments being of very considerable significance for the structure of the due understanding of ulcer disease. For instance, the fact that some-

times shows cases clinically diagnosed as ulcer, but in laparotomy without undisputable anatomical ulcer changes (scars, craters, etc.). Among these cases there are 40 per cent. with no improvement, or worse, after operation, while the corresponding figure for all other operated ulcer cases (*i.e.*, with absolutely obvious chronic ulcer changes) shows just 10 per cent., this fact thus urging the surgeon in such negative cases to refrain from any operation on the organ in question. These negative cases with bad operative results are to a considerable extent neurotic individuals. Moreover, in the remainder of the ulcer patients, too, on closer scrutiny, signs will be found that point to an etiological significance for ulcer of constitutional, neurogenous, and spastic moments: general neurotic symptoms, signs of Graves's disease, psychoses, epileptoid attacks, tabes dorsalis, etc. (not to mention the signification of the so often seen spastic hour-glass stomach, pylorospasm, gastrospasm, etc., or the results of experimental clinical and purely experimental research concerning vagotonus and sympatheticotonus).

ANNULAR SEGMENTAL GASTRECTOMY*

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In selected cases, the removal of a segment from the stomach appears to leave the organ with as efficient motor power as can be secured by any other resection of a corresponding amount of stomach tissue. In a previous communication, it appeared the stomach's emptying capacity following segmental gastrectomy was not equal to that of a normal stomach but greater than that of a stomach with a saddle-shaped piece removed from the lesser curvature. No explanation was offered for the stomach's respective behaviors after these resections. The following opinion was expressed: "This difference in the emptying times may be due in part to the mechanical relations incidental to the gastrectomies themselves but more probably due in greater part to the fundamental disturbances in the neuromuscular motor mechanisms of the stomach." This has been taken as a working hypothesis for further experimental and clinical study which forms the basis of this paper.

1. *The Neuromuscular Motor Mechanism.* — The intrinsic nervous connections of the stomach are complicated and defy identification. It is fully realized that the vagi, themselves, are not pure cerebrospinal nerves but systems of central and sympathetic fibres to which are added other communications before and after their passage into the walls of the stomach. Other nerve groupings, styled the sympathetic nerves, obviously may not be purely autonomic for a similar reason but, on the other hand, may contain vagus elements. The constancy of any fixed proportion of central or of autonomic fibres in either extraneous nerve grouping is not and, so far as is known, cannot be determined; hence the futility of predicating gastric symptoms and signs to the impairment of either vagus or sympathetic nerve. In the accompanying drawing, the branches of the anterior vagus and the blood supply are represented in detail; if to the nerves indicated are added the great meshwork of sympathetic fibres that everywhere imbed the several vascular branches, some idea of the complexity of the nervous connections is obtained.

It is not surprising that the terms "vagotonia" and "sympatheticotonia" when applied to gastric symptom-complexes are unproductive as working diagnoses. It is similarly hazardous to ascribe very much significance to experiments based entirely upon divisions of these nerves.

Most of the reported experiments are the direct observations of the experimenters or are the inferences drawn from the observed phenomena. Braun and Seidel[1] cut the spinal cord and noted the incompacity of the stomach to

* Read before Ex-interne Soc., M. E. Hosp., April 26, 1917.

[1] Braun and Seidel: Mitteila d. Grenzgeb, d. Med. u. Chir., Bd. 17, S. 533.

expel gas; they severed the vagi and found the emptying power to be present or absent and emetics to be powerless. Friedenthal [2] recorded no diminution in assimilation, digestion, and other functions after division of both vagi and splanchnics. Langley [3] held that the intrinsic stomach apparatus reduced by one-half the stomach volume by forcible contractions. Magnus and others reported movements of circular and longitudinal muscle when left in contact with Auerbach's plexus. Unger [4] found acute dilatation followed the division of the vagi in the chest. Others have corroborated these workers or have applied themselves independently in correlated studies.

The technic has been modified since the last series of experiments were reported (AN. OF SURG., Nov., 1916, vol. lxiv, p. 527). There are so many advantages in an open laparotomy over the visualized stomach or in the intragastric bag method that it has been used almost exclusively in the following study of the gastric motility, reserving the latter two resources as controls on the former or for the purposes of securing permanent graphic records. The activity phases outlined in the earlier paper have been taken advantage of by feeding each subject preliminary to celiotomy a comfortable amount of diluted meat extract. The effects of ether, morphia, and trauma have been studied especially in relation to the element of time which enters into all experiments and as far as possible have been controlled. Each experiment is carefully written up and preserved. For convenience, the respective numbers, only, will be mentioned hereafter. (The numbers apply to experimental animals represented in the accompanying chart, entitled, "Résumé of Experiments Upon the Dynamics of the Stomach.")

Vagotomy was performed in five animals (123, 126, 134, 144, 171). *Thoracic section of the vagi* in these animals was associated with *a more rapid, more superficial fundic wave and an independent forcible pro- and anastaltic pyloric wave.* From this observation, it might be inferred, subject to further experimental proof, that the vagi carry motor fibres to the fundus and the inhibitory motor fibres to the pyloric portion. (This finding [5] is not new but corroborative of those experimenters who have held similar functions for the gastric fibres of the vagus.) Attempts have been made to associate motor changes with the corresponding divisions of extraneous sympathetic nerves but without apparent success.

The intrinsic apparatus is intimately bound up with the blood and vessel system. It is obviously impossible to clamp, ligate, or divide any of these nerve fibres without at the same time equally interfering with the vessels, muscle, and supporting fascia of the stomach or without, in other words, performing stomach block experiments. Of this character are the following experiments. Incisions were carried astride of the lesser curvatures of the stomachs (in the pyloric regions of most animals or in the adjoining fundic

[2] Friedenthal: Arch. f. Anat. u. Physiol., 1904, S. 579.
[3] Langley: Proc. Physiol. Soc. Lond., 1911, xiii, xxiv.
[4] Unger: Vide Friedmann, Arch. f. Verdauungskrank Erganz, Bd. 17.
[5] See Howell, W. H.: Text-book Physiology, p. 665, 1907.

portions of many others and, in one, in the vicinity of the cardia) half the perpendicular distances to the greater curvatures on both surfaces of the stomachs down upon or through the mucosa or saddle-shaped sections were removed; similarly, incisions were made completely about the gastric tube or annular segments were resected.

Under the conditions of incomplete blocking in seven animals (100, 101, 144, 149, 161, 165, 173) and making allowances for slight variation, it appears that *"triangular" gastrectomy was followed by more rapid, more superficial, fundic waves and more superficial, incomplete pyloric waves.* During the preliminary clamping and ligation there were stronger and slower waves (see Experiments). The peristaltic contractions started high up on the lesser curvature close to (probably actually at) the cardia, traversed the stomach body, and disappeared in the proximal portions of the pyloric end of the stomach. The tonus of the fundus of the "triangularly" resected stomach appeared on the whole equal to or less than that of the unimpaired gastric fundus; the tonus of the pyloric portion, definitely less than that of the normal pyloric end.

In eleven animals (134, 100, 101, 101 six weeks later, 96, 96 six weeks later, 149, 165, 161, 144, 173) after making due allowance for slight variation, it appears that *"segmental" gastrectomy was followed by normal or stronger fundic waves and independent forcible pro- and anastaltic pyloric waves.* For the first few minutes to one hour following necessary manipulation, the waves in the fundic part were superficial. The tonus of the fundic part appeared equal to or greater than that of the normal stomach; that of the pyloric part, markedly greater.

When triangular resection or partial blocking of the caudad stomach is compared with segmental resection or complete blocking it will be seen that the latter method is associated with the more normally balanced fundus and the more actively efficient pyloric part. Furthermore when the effects of thoracic vagotomy upon the pyloric portion are compared with those of segmental blocking, similarity again is found; in other words, the division of the two vagi in the thorax has the same influence upon the motility of the pyloric end of the stomach as severance of the neuromusculature at the pylorofundic junction. These observations agree with the inference offered above after vagotomy; namely, that the vagi carry inhibitory motor fibres to the pyloric portion of the stomach. It appears, therefore, that triangular gastrectomy allows some of these fibres to hold the intrinsic motor apparatus of the pyloric part in check but that segmental gastrectomy removes these inhibiting fibres. In respect to the fundic portions, it will be noted that the body of the stomach is reduced in tone and force of contraction after incomplete blocking and after thoracic vagus section but left with tone and contractions more resembling the normal experimental fundus after complete blocking. It is possible that the centripetal fibres play an important rôle in these latter relationships but, other than this suggestion, no explanation is attempted.

FIG. 1.—Drawing of human stomach from cast and from dissected specimen lent by Senior. Note blood supply and extensive ramifications of anterior vagus. Note, also, normal vertical position of organ.

FIG. 2. FIG. 3.

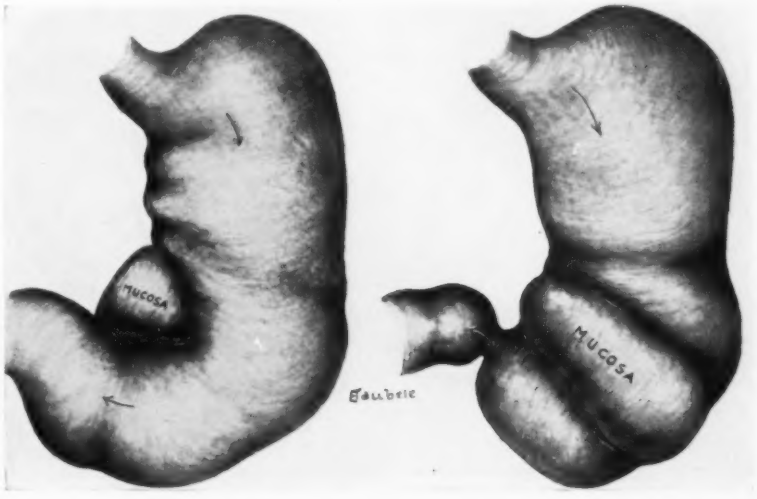

FIG. 2.—Experimental triangular gastrectomy indicating superficial peristaltic contractions of fundus and relatively amotile and atonic pyloric part.

FIG. 3.—Experimental annular segmental gastrectomy indicating a one-cycle, fairly tonic fundus and an independently motile and hypertonic pyloric part.

FIG. 4.—Persistent three-cycle type motility four weeks after operation. Compare with Fig. 3.

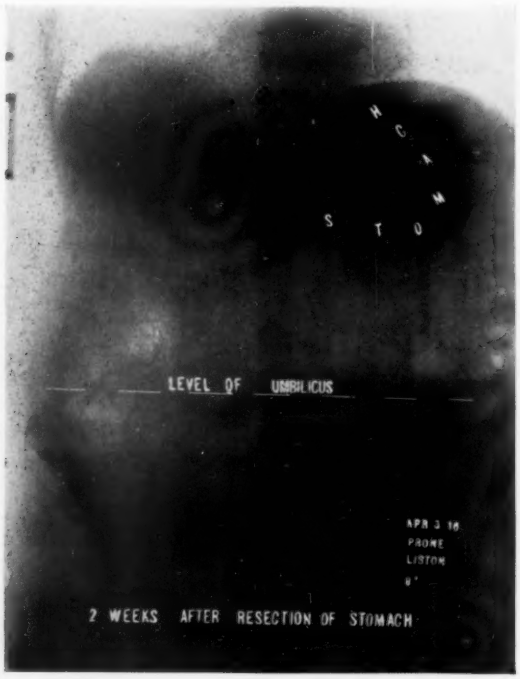

FIG. 5.—The more characteristic picture after annular segmental gastrectomy. Note pyloric part not demarcated. The exposure evidently coincides with a phase of pyloric hypermotility commonly observed experimentally.

These experimental data correspond with experience in human segmental resection for gastric ulcer. A parallelism exists in comparative fluoroscopic studies; also, in human or in canine röntgenograms; and in observations upon resected brute animals (Cf. X-rays of human cases with Fig. 3). The fundi often require six hours for emptying; many stomach bodies have normal tone and good motility. The pyloric segments often do not appear upon the X-ray prints: this accords with the hypermotility or with the tetany of the distal portions observed in some of the experimental resections.

CASE I.—Mr. J. S. V. referred to by Dr. J. Nolan, Aug. 17, 1916. 36 years. Portuguese. Business man. Always constipated. Epigastric pain increasing in severity during past four years. Loss in weight. Rigidity and tenderness over upper right rectus. Le Wald reported probability of gastric ulcer. August 30, 1916, annular segmental gastrectomy for ulcer at lesser curvature in pyloric region. Pathological report: "Gastric ulcer highly suspicious of early malignant change." Four weeks postoperative residue less than half; condition very satisfactory. At present time reports himself back in business and entirely free from all gastric symptoms.

CASE II.—Miss M. McG., case of Dr. J. M. Lynch. Trained nurse. 28 years. U.S.A. Diarrhœa since July, 1916. Epigastric pain 5-6 hours after eating—began 10 years ago. Loss in weight. X-ray showed "almost complete obstruction of the stomach." November 17, annular segmental gastrectomy for gastric ulcer. Pathological report: "Gastric ulcer." Six weeks postoperative the six hour residue was considerably less than the nine hour residue before operation. She reports herself well and comfortably working at her occupation.

CASE III.—Mr. H. S. referred by Dr. Matusoff, April 25, 1917. 32 years. Russian tailor. Constipation past 5 years. Epigastric pain, worst after eating, past two years. Loss in weight. Stomach dilated. Hobbs (May 7) reports "almost complete pyloric stenosis with resulting dilatation." May 9, 1917, pylorectomy. Pathological report: "Pyloric ulcer with no recognizable evidence of malignancy." No unfavorable postoperative gastric symptom.

A locus of initial pyloric motility has been observed particularly in those stomachs showing independent pyloric rhythm. This site includes the gastric segment making up the incisura angularis. Its most motile point appears to lie at the junction of the first large branch of the right gastric artery with the lesser curvature of the stomach. Further research is necessary to establish possible nodal significance for this centre. (For convenience this "centre" is hereafter spoken of as the "C-point.")

2. *The Mechanical Relations.*—According to the methods above described, the loss of tissue and the resulting scar are greater after segmental than they are after triangular gastrectomy. Whatever applies to obstruction due to the presence of or to the contraction of the cicatrix should pertain more forcibly to the former method. From experience in pyloric occlusion, it appears that persistent total obstruction of the physiologic outlet of the

stomach is a diffcult process even when it is purposely attempted. However, were it possible, notwithstanding one's exertions to the contrary, to seriously obstruct the stomach in performing one of these gastrectomies, it obviously must depend upon the resulting scar tissue.

Stricture is said to follow entero-enterostomy of nonperitoneal covered intestine. In experiments completed by the author it appears that all such productive inflammation after intestinal wounds has a rather more definite relation to the vascular supply of the apposed edges. This idea evidently prompted the " elbow " operation and other similar contrivances. The following experiment suggests this correlation of impaired blood supply and redundant gastric scar:

Dog No. 168 after morphine-ether and the usual preparation—Stomach divided in two transverse planes and closed by sutures; one, the aboral incision by a Connell suture, being careful to draw in the separate bites so as to *appose* the cut edges, the other, the oral, a Shoemaker stitch with two needles and oppositely drawn suture material *tautly pulled in to the point of strangulation of the edges* of the stomach wound. Two weeks later, this latter wound although it involved the thinnest portion of the stomach sac was much more indurated and on cut section showed much more and firmer fibrous tissue.

Whatever be the cause of harmful scar tissue after gastrectomy, it ought to apply more to the stomach with the greater wound: segmental gastrectomy.

The mechanical removal of tissue from one curvature and not from the other, as in the triangular method, may result in a deformed stomach but it does not explain the deficiency of tone and the absence of contractile wave in those stomachs, above represented, in which the mucosa was left intact and the original dimensions of the stomachs preserved.

Résumé.—The removal of an annular segment from the stomach leaves the stomach with greater emptying power than the removal of a saddle-shaped section from the lesser curvature. This relationship is probably dependent upon the discontinuance in the neuromusculature and not upon the mechanical results of the respective operative procedures.

The writer wishes to thank Professor H. D. Senior of the Department of Anatomy, New York University and Bellevue Medical College, for his generous coöperation in the surgical anatomy. He is also indebted to Mr. A. Diem, the Laboratory technician, for his assistance with the experimental animals.

RÉSUMÉ OF EXPERIMENTS UPON THE DYNAMICS OF THE STOMACH

No. 311. Gastric wave begins at cardiac end of lesser curvature.

No. 206. Double clamping lesser and greater curvatures at corresponding points gives strong pyloric contractions; rate 1.3 cm. per sec.; recurrence, q. 21 sec.

No. 274. Cat's stomach of 2–3 cycle variety; recurrence of waves q. 20 sec. Clamping half across from the lesser curvature gives more forcible pyloric waves; clamping all across gives blocking of pyloric waves.

No. 24. Dog's stomach of 2–3 cycle variety. Relation of motility to ether;

waves decrease in height, force and rate but increase in regularity as ether coma approaches; waves increase in height, force, and rate becoming tetanic as the ether is withdrawn. Relation to "C-point": Clamping of C-point gives waves more rapid and increase in tone of fundus.

No. 25. Triangular gastrectomy gives weak waves in pylorus which become through waves from cardia.

No. 96. Segmental gastrectomy (Iwk. p. o.); Waves of 1 cm. per sec. in fundus; independent same time rhythm, pro- and anastaltic in pyloric part.

No. 100. Under morphine-ether waves normal recurrence time is q. 25–21 sec. After triangular gastrectomy recurrence time is 14 sec. After segmental gastrectomy independent rhythm of pyloric part.

No. 101. Under morphine-ether waves normal recurrence time is q. 25 sec. and rate 1.4 cm. per sec. After triangular gastrectomy recurrence is 14.75 sec. becoming more rapid, frequent, and superficial. After segmental gastrectomy (whether incision closed or not) tonic fundic part; atonic pyloric part with independent rhythm and waves infrequent, forcible, pro- and anastaltic.

No. 111. Vagi? Three branches anterior vagus below diaphragm clamped gives waves slower and more superficial (trauma necessarily considerable).

No. 117. Vagi? Anterior and posterior vagus above diaphragm cut gives waves of moderate force in pyloric part. CO_2? CO_2-blood gives increase in tone, localized contraction, total disappearance of contractions, general relaxation.

No. 123. Vagi? Both vagi cut above diaphragm gives waves forcible in pyloric part; relative amotility in fundic part or waves superficial, frequent, and difficult to follow. C-point, clamped, gives waves less forcible and more frequent in pyloric part.

No. 126. Vagi? Vagi cut above diaphragm gives increase in tone of whole stomach; increase in frequency of fundic waves; increase in force to all waves; does not alter rhythmicity of pyloric waves which are occasionally anastaltic.

No. 128. C-point, ligated, gives weak fundic waves disappearing at C-point, and traceable with difficulty beyond in pyloric part; decrease in tone.

No. 134. C-point, clamped, gives waves more forcible in fundus. Vagus ends divided at level of C-point gives in fundus waves rapid and superficial; in pyloric part, waves more forcible approaching tetany and independent rhythm. Vagi? Vagi above diaphragm cut gives waves weak in fundus.

No. 144. Triangular gastrectomy gives waves deep in fundus; superficial in pyloric part. Segmental gastrectomy gives waves of independent rhythm with pro- and anastalsis in pyloric part (whether wound in stomach closed or gaping). Splanchnics in chest cut gives waves no change. Vagi in chest cut gives waves shallow in fundus; no further change in pyloric part.

No. 149. Waves normally recur at 18 sec. intervals. Clamping of C-point gives waves of fundus more forcible but slower; waves of pyloric part more forcible and anastaltic. All waves decrease in tone 5 min. later. Suture? Pyloric waves forcible, anastaltic to suture; fundus waves forcible. Triangular gastrectomy gives fundic waves superficial to 1 cm. of incision; tone plus. Segmental gastrectomy gives fundus waves as after triangular gastrectomy; recurrence time 15 sec.; tonus same. Pyloric waves superficial pro- and anastaltic, localized about distal cut edge; tonus same; recurrence q. 18 sec. Anastomosis does not alter these waves. Cutting of vagi in chest 95 min. after laparotomy gives no additional change.

No. 96. Segmental gastrectomy six weeks postoperative shows tonus of fundus normal; waves superficial and infrequent; tonus of pyloric part normal, waves forcible and tetanic. No mechanical obstruction.

No. 101. Segmental gastrectomy six weeks later gives tonus of fundus subnormal; motile pyloric part. No mechanical obstruction.

No. 161. Normal stomach gives "through" waves, two at a time, weak, at 22 sec. intervals, and continuous. Triangular gastrectomy gives waves same or stronger, at 20 sec. intervals in fundic part and after the first 2 to 5 min. weak and gradually disappearing in the pyloric part. Segmental gastrectomy gives waves more superficial in fundic part and absent in the atonic pyloric part.

No. 165. Normal stomach gives waves q. 15 sec. occasionally retroperistaltic, moderately forcible, continuous 2 cycle. Suture at C-point gives localized retroperistalsis beginning 1 cm. to right on lesser curvature and extending to the suture. Incomplete division of the stomach perpendicularly toward the greater curvature from C-point gives retroperistalsis from pylorus to cardia, waves q. 17 sec.; ½ hr. later normal prostaltic waves disappearing in the pyloric part. Complete division gives waves at first weak in fundus and pyloric part, 53 min. later waves forcible in both parts; q. 20 sec. in fundus and q. 40–60 sec., retro- and prostaltic in pyloric part.

No. 171. Waves (normal) in fundus strong and prostaltic; in pyloric part occasional retrostaltic waves intercepting strong prostaltic wave. Vagi divided in chest gives waves in fundus superficial and traceable into pyloric part, later to C-point, only; in pyloric part waves generally retrostaltic to fundic waves; later strong to C-point only (with an occasional prostaltic wave). Sutures placed at C-points serve only to enforce the above as does complete division of the stomach between these points.

No. 172. Triangular gastrectomy gives fundic waves superficial, strong in vicinity of incision, three at a time appearing on the lesser curvature; pyloric waves which are the prostaltic fundic waves disappearing early in the pyloric part; good pyloric tonus. Segmental gastrectomy gives fundic waves 1–2 at a time, weak or occasionally strong; pyloric waves independent pro- and anastaltic to within 1 cm. of incision.

No. 173. Triangular gastrectomy gives a moderately forcible 2–3 cycle fundus and a relatively atonic pyloric part with no waves barring the disappearing fundic waves in its proximal portion. Segmental gastrectomy gives a moderately forcible 1–2 cycle fundus with a moderately forcible pro- and anastaltic pyloric part. Site of gastrectomy as near to the cardia as possible.

"C-point" refers to site of special pyloric motility alluded to above.

By the "pyloric part" is meant that part of the stomach distal to the antral sphincter or incisura; the "fundic part," that proximal.

Note that the pyloric part behaves very much as a functional entity. It may be reasonable to speak of the surgical and of the anatomical pylorus, meaning by the former the whole pyloric portion invested by the thicker bundles of circular muscle fibres and of the anatomical pylorus as that commonly understood; namely, the termination of the pyloric end of the stomach canal indefinitely defined as from one-half to one inch in extent.

STRICTURE OF THE GALL-BLADDER

DUMB-BELL GALL-BLADDER

By W. Frank Fowler, M.D.

of Rochester, N. Y.

The writer apologizes, as his predecessors have done when reporting a case of so-called hour-glass gall-bladder, by stating that in this particular instance there are unique features of unusual interest. As regards the actual frequency of this type of deformity Dr. W. C. MacCarty[1] states, in a personal communication to the writer, that it was encountered at the Mayo Clinic 31 times in a series of 3692 gall-bladders.

We are indebted to Else[2] for an excellent description of gall-bladder strictures based upon his post-mortem investigation of 1100 gall-bladders. Else reminds us that this subject has not received the study and consideration which it deserves. Gall-bladder strictures may be either congenital or acquired, although most observers have considered them as being of acquired origin only. Else bases his opinion that many such deformities are congenital upon his findings in very young infants, one being present in a baby dying within twenty-four hours of birth.

"Uncomplicated congenital strictures in adults can be distinguished by the fact that there is an absence of the evidences of inflammation and by the fact that the characteristics of the congenital strictures differ from those of the acquired type. It is, however, often difficult to differentiate, from acquired strictures, congenital strictures in which changes have taken place due to an infection and gall-stone formation. Congenital strictures predispose to infection and gall-stone formation and these in turn to ulceration and scar formation."

Else classifies congenital strictures into three types:

1. Annular strictures.

2. Those due to the projection of folds of the inner layers into the lumen.

3. The fundus stricture or elbow deformity in which the fundus is folded upon the body of the gall-bladder. This is the most usual type.

Acquired strictures, according to Else, may arise from:

1. Destructive lesions beginning with the mucosa. The ulceration and deformity may be due to infection alone or to infection plus pressure necrosis from stones. Constriction varies from that of slight degree to typical hour-glass contraction with almost complete obliteration of the lumen.

2. Intramural infections. These may originate either from infected Luschka ducts or from bacteria or infected emboli brought through the cystic artery.

3. Pathological processes beginning with the serosa. The pathological process may be a part of a general or local peritonitis.

4. Adhesions existing between the gall-bladder and other organs or the abdominal wall.

5. Chronic indurative processes are responsible for strictures as well as for shrunken or so-called atrophic gall-bladders.

6. Perforating wounds.

7. Malignant strictures.

Under the title "Congenital, Almost Complete, Separation of the Gall-bladder into Two Cavities," Morton [3] states that hour-glass gall-bladder is not uncommon. In Morton's case the fundus of the gall-bladder formed a pocket consisting of about one-third of the organ which communicated with the proximal part by an extremely minute opening. The gall-bladder was of normal size, the wall was not thickened and there was no scar tissue. The distal sac contained 50 stones and a little bile, the proximal part was filled with 65 stones. Morton quotes Malcolm [4] as reporting a similar condition, but Malcolm believed the constriction in his case to be caused by cicatricial contraction.

Fowler [5] notes, also, that hour-glass gall-bladder, *per se,* is not sufficiently rare to warrant extensive report. In Fowler's case a stone the size of a hazel-nut and mucopus occupied the upper pocket from which a passage less than one-quarter inch in length, with a quarter inch thick wall, and admitting only a fine probe, led into the lower sac which contained thick, grumous material. The lower pocket was larger than the upper and the walls of both were much thickened. There were many adhesions about the gall-bladder which rendered cholecystectomy unduly difficult and inadvisable, although indicated. There was also a stone in the common duct.

The author's case is as follows:

> Mrs. H., aged fifty-seven years, for the past six years has had, annually, one or two attacks of pain in the lower right side which were diagnosed as appendicitis. Her bowels have been irregular since childhood. She has had stomach trouble during the last six years, off and on, with burning in the stomach and vomiting. She ascribed her gastric disturbance to injudicious eating and so starved herself during these attacks. She has never had typhoid fever nor has she been pregnant (infantile uterus).
>
> *Pre-operative Examination.*—Tenderness was elicited over the appendix. Diagnosis, chronic appendicitis.
>
> *Operation.*—Many adhesions were encountered between the omentum and the peritoneum. The appendix showed chronic inflammatory changes and was removed. Examination revealed a shrunken gall-bladder containing two stones. After separation of adhesions between the liver and the peritoneum the liver was rotated and cholecystectomy performed. There were adhesions in the gall-bladder region, but none of the gall-bladder itself. Operative recovery has been satisfactory.

FIG. 1.—Dumb-bell gall-bladder.

Examination of Specimen.—The excised gall-bladder was approximately 7 cm. in length. It presented a peculiar appearance. There were two round portions of uniform size, one at the fundus, the other at the neck, with contraction of the part between into a narrow, straight isthmus. The wall was greatly thickened, particularly about the expanded portions, each of which contained a stone the size of a large marble. The lining of these pockets was smooth and white and encircled the stones snugly. The stone at the neck of the gall-bladder was firmly adherent at one point. The gall-bladder contained no bile but merely a few drops of white mucoid fluid characteristic of cystic duct occlusion.

Comment.—The designation, hour-glass gall-bladder, has been utilized by Else and others to indicate varying degrees of asymmetrical distortions resulting from cicatricial contraction following ulceration. Since the writer's case was characterized by striking symmetry he ventures to suggest, as descriptive of this particular type of deformity, the term, dumb-bell gall-bladder.

From a study of 365 gall-bladders Irwin and MacCarty[6] divide cholecystitis into eight classes, one of which, cholecystitis chronica cystica, is described thus: "A stone was frequently found lodged in the cystic duct or in the valves of the neck of the gall-bladder, thereby causing obstruction and distention of the organ. This resulted in thinning of the wall and destruction of the mucosa or flattening of the scar tissue ridges in the chronic cases. The stone was usually firmly imbedded between the valves and could not be moved in either direction. Microscopically the wall was a thin layer of connective tissue in which traces of the nuclei of the muscle-cells were sometimes found. Such a gall-bladder attained great size and was usually the type which presents itself as a large palpable tumor."

Although differing markedly from the foregoing description, the author's case was undoubtedly one of cholecystitis chronica cystica. The deformity might be classified, according to Else, as one due to chronic indurative processes.

A stone which is apparently impacted in the neck of the gall-bladder (as in the writer's case) in reality may be lodged low down in a dilated cystic duct dangerously close to the hepatic and common ducts. The latter, therefore, should be positively identified.

REFERENCES

[1] MacCarty, W. C.: Personal communication.
[2] Else, J. Earl: Strictures of the Gall-bladder. Surg., Gynec. and Obstet., October, 1914.
[3] Morton, C. A.: Congenital, Almost Complete, Separation of the Gall-bladder into Two Cavities, Each Containing Gall-stones. Brit. Med. Jour., December 5, 1908.
[4] Malcolm: Quoted by Morton.
[5] Fowler, R. S.: Hour-glass Gall-bladder. N. Y. Med. Jour., June 3, 1916.
[6] Irwin, H. C., and MacCarty, W. C.: Papilloma of the Gall-bladder. ANN. SURG., June, 1915.

Examination of Specimen.—The excised gall-bladder was approximately 7 cm. in length. It presented a peculiar appearance. There were two round portions of uniform size, one at the fundus, the other at the neck, with contraction of the part between into a narrow, straight isthmus. The wall was greatly thickened, particularly about the expanded portions, each of which contained a stone the size of a large marble. The lining of these pockets was smooth and white and encircled the stones snugly. The stone at the neck of the gall-bladder was firmly adherent at one point. The gall-bladder contained no bile but merely a few drops of white mucoid fluid characteristic of cystic duct occlusion.

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TUMORS OF THE BLADDER

WITH REPORT OF 26 CASES

By H. W. E. Walther, M.D.
of New Orleans

There is probably no affection coming under the observation of the urologist in which modes of diagnosis and treatment have changed so radically, within the past decennium, as has been noted to have taken place in dealing with neoplasms of the urinary bladder.

The final perfecting of the cystoscope and the more extensive use of this valuable instrument *in all cases of hæmaturia* has undoubtedly made it possible to diagnose vesical growths more frequently and at a much earlier period than was formerly the case. Then, too, the histopathological study of these tumors, so thoroughly investigated recently by Buerger, has aided materially towards our determining the character of these growths. Buerger has advocated obtaining material for pathological study by either recovering tumor particles in the bladder washings or by deliberately snipping off a piece of the tumor through an operating cystoscope by means of punch forceps. While the latter method has not been universally accepted, because of the ever-present danger of disseminating malignant cells when dealing with vesical cancer, I believe that when sufficient material can be collected by safer means (as from bladder-washings) it should always be submitted to a competent pathologist for study.

A statement which has repeatedly found its way into print within the past few years is: That the clinical diagnosis and the pathologic findings in tumors of the bladder are invariably diametrically opposite. The writer cannot agree with this dictum. To the contrary he has found the clinical diagnosis of a given case repeatedly confirmed by the microscopist and in any number of instances has found the pathologist's opinion of distinct value. Only too few urologists interest themselves in surgical pathology. Were the operator to carefully follow his cases, not only postoperatively in the sick room, but follow specimens removed, to and through the pathological laboratory, he would find the time so spent of inestimable value in perfecting his diagnostic acumen.

Whereas, in the past we have been led to believe that bladder tumors constitute but 3 per cent. of all diseases of the urinary organs and from .3 to .7 per cent. of all tumors occurring in the human body, one cannot help but feel that with the continued aid of modern urological diagnostic aids, more extensively employed, these figures will require an upward revision.

The one main point in the successful management of these cases, if a cure is to be expected, is an early and a correct diagnosis. Chute has ably pointed out that the tardy recognition of bladder tumors is not due

to a lack of symptoms in most cases, but to a lack of a just appreciation of the significance and importance of symptoms. Of the three cardinal symptoms of vesical growth, viz., hæmaturia, pain and frequency, hæmaturia plays by far the most important rôle. For a number of years past, various urologists have pointed out that hæmaturia is probably the most common early sign of bladder tumor. And yet, as is shown in my personal records, the time which had been allowed to elapse between the first appearance of blood in the urine and the time at which a correct diagnosis was made is perfectly astounding. In two of my cases the interval was fifteen years.

Whether the fault lies with the general practitioner, in failing to send these patients to those properly equipped to make an early diagnosis, or with urologists themselves in their failure to acquaint the general practitioner with the necessity of speedily subjecting every case of hæmaturia to cystoscopy so that these growths can be gotten in their incipiency—this is a question I am unable to answer intelligently. However, the propaganda for the dissemination of knowledge in regard to the early diagnosis of cancer, so enthusiastically wagered in the past few years by many of our leaders in American surgery, has extended equally into the domain of urology and urological literature, and many valuable contributions have appeared which, if read, should exert no little influence towards making all practitioners of medicine cognizant of the fact that when they are called to see a case of hæmaturia no time should be lost in administering internal medicaments and passing lightly on the occurrence of blood in the urine of their patients. Only too frequently this is the first sign evidenced of cancer.

We know that these bladder tumors may be primary or secondary growths; that they may be benign or malignant. Some writers further divide them into (*a*) epithelial, (*b*) connective-tissue, and (*c*) muscular-tissue tumors. It is generally conceded, I believe, that most benign neoplasms, with few exceptions, arise primarily in the viscus, whilst quite a number of the malignant tumors found in the bladder are metastases from the kidney, or extensions by contiguity from tumors in the prostate and abdominal and pelvic viscera. Of the benign types we commonly see papillomata, angiomata, fibromata, myomata, adenomata and cysts; of the malignant types we get carcinomata, sarcomata and myxomata.

Numerous theories have been expounded regarding the causation of primary bladder growths. Previous inflammation is supposedly a common causative factor. These tumors have been commonly noted among aniline-dye workers. Bilharzia as well as stone in the bladder undoubtedly play a part in the etiology of some cases. Of the secondary growths in the male the prostate must be considered a frequent offender. Montford found in the examination of 78 epithelial tumors in men that 27, or 35 per cent., showed cancerous extension from the prostate. In the female, malignancy of the cervix or of the uterus proper causes a certain percentage of secondary bladder tumors.

The question frequently arises as to when are bladder tumors clinically benign and when are they malignant? Many to-day feel that much confusion

has been caused by referring to benign and malignant papillomata, alluding to the microscopic picture rather than to their clinical course, in giving an impression that we have in the bladder a variety of tumor that is and remains clinically benign. We know such is not the case. That even the most innocent papillomata are potentially or actually malignant. Some writers go as far as to say that the term "benign tumors of the bladder" should be eradicated from our medical nomenclature because of its aptitude towards deception. The consensus of belief to-day is that all tumors of the bladder are clinically malignant and that unless removed by some surgical means will, either directly or indirectly, cause the death of the patient. Particular attention is given to the papillomata because they are by far the most frequent type of neoplasm met with in surgical urology. Of 113 vesical tumors recently studied by Buerger, 55 were papillomata, 45 were papillary carcinomata, 5 were squamous carcinomata, and 6 were sarcomata.

When we come to consider the treatment of this condition we find that opinions have been divided as to what method of procedure best to follow. For many years suprapubic cystotomy with excision of the growth, either by knife or scissors, and then cauterizing tumor base with actual cautery, was the method in vogue. Recurrences rapidly followed all such procedures. Then resection of the tumor with an area of healthy bladder wall, cutting through all the layers of this viscus, was practised, but again implantation of tumor cells and subsequent reappearance of growth at operative site and frequently in suprapubic scar demonstrating that this method was far from ideal. In fact all cutting operations on the bladder for tumor, especially when growth involves trigonal area, have been disappointing. Watson has advocated total cystectomy for extensive malignant involvement of this viscus and has one case that is living and well eighteen years after total removal of the bladder with bilateral nephrostomy. Some few cases of cystectomy have been successfully carried out according to reports recently appearing in the literature. The procedure has not, however, received universal indorsement by urological surgeons. Rafin collected 58 cases of total extirpation in which the operative mortality was 50 per cent. This high death rate at operation undoubtedly accounts for the lack of enthusiasm shown in this procedure. The subtotal cystectomy as advocated by Squier may obtain favor especially in dealing with malignant growths involving only the bladder vertex. For resecting areas of malignancy in the bladder wall the cautery seems to have succeeded the knife, for obvious reasons. Gardner's recently reported collection of 1702 operated bladder tumor cases demonstrates conclusively the limited field of scalpel-surgery for the permanent relief of this condition.

In 1910 Beer first reported his results in destroying papillomatous growths of the bladder by employing high-frequency electrical current in the form of a spark-cauterization directly applied to these neoplasms by means of an electrode introduced into the bladder through an ordinary catheterizing cystoscope. This work has since revolutionized bladder tumor surgery. In the opinion of the writer this monumental work of Beer has

not received the full recognition it so rightly deserves. Surgeons generally do not fully appreciate of what inestimable value this method is to us. When we consider that by intravesical high-frequency cauterization we can, with a few painless applications, cause papillomatous growths to disappear as if by magic and not recur after a careful observation already extending over a period of seven years, and when we again consider the poor results and frequent recurrences in the cases treated by the older methods, we cannot look upon this new way of treatment in any other light than marvellous.

In this high-frequency cauterization procedure two currents have been used. The first one, advocated by Beer, is the Oudin or monopolar spark and is the one most widely used to-day by urologists because of its marked focal action at the point of application producing cauterization and coagulation of tissue. The second current is the d'Arsonval, or bipolar, which has less local action but its distant action, coagulation by heat, is more marked. My experience has been with both types, but I consider the Oudin current far superior to the bipolar method for destroying papillomatous excrescences. Unfortunately, high-frequency cauterization is not applicable for all types of tumor of the bladder. It is generally conceded to-day that it will destroy most papillomata—whether benign or malignant. However, in malignant tumors of a sessile type this treatment is only applicable for the checking of hemorrhage, for it will efficiently stop a bleeding-point with but a short application. As for destroying the malignant growth itself, it has not been found a success.

For malignant vesical neoplasms which in the past have been considered almost beyond any kind of tangible surgical relief, *radium* has opened up a new and fertile field. The possibilities of radium in the treatment of malignant growths have not yet been definitely determined. Surely much good has already been accomplished by its use, and as the action of the element is more thoroughly understood much more good will be accomplished. Among urologists, Young, Barringer and Ayres have published preliminary reports on results obtained with radium in the treatment of cancer of the bladder, particular attention being paid to the inoperable type of malignant bladder growth. Their results obtained so far are indeed encouraging. The applications are made by introducing a capsule of radium, screened with silver and rubber, into the bladder through the sheath of a cystoscope. Some workers have designed special cystoscopes for carrying the radium in the beak of the sheath, as in the Ayres instrument. The most ingenious instruments yet brought forward for this work are the radium cystoscopes of Young. In line with the usual thoroughness to be found in anything that Young attempts, he constructed three different models of radium-carrying cystoscopes, one for making applications to the neck of the bladder, trigone and certain parts of the lateral and posterior vesical walls, a second for treating tumors well out on the lateral walls or on the upper part of the anterior wall, and a third especially adapted for tumors located on the posterior bladder wall. These instruments have been thoroughly tested out by their talented originator in the Brady Urological Institute

for three years past, and have, in a large series of cases, demonstrated beyond a doubt their practicability.

At the Radium Institute of New Orleans a number of cases of advanced malignancy of the bladder have received treatment. The method there of applying the radium has been by placing the capsule in the end of a rubber urethral catheter and then introducing the catheter into the bladder and allowing it to remain for a certain given length of time. The results obtained have been encouraging. However, sufficient time has not elapsed and the number of cases treated to date is not large enough to warrant forming definite conclusions. It is the belief of my colleague, Dr. E. C. Samuel, director of the Institute, that in these cases, in order to obtain the best results, applications should be made preferably through a suprapubic permanent opening.

My reasons for presenting the twenty-six cases of tumor of the bladder which have come under my observation are twofold. Firstly, by reporting my successes with transurethral high-frequency cauterization of vesical papillomata, to add my modest commendation to the procedure introduced by Edwin Beer as being the greatest boon yet rendered to urological surgery in the management of this type of neoplasm. And secondly, to show, by case reports, the futility of scalpel-surgery in dealing with advanced malignant growths of this viscus, when considered from the standpoint of permanent cure. That a new day has dawned and that in the future we shall find in *radium* an agent powerful enough to destroy many of these dreaded growths is a hope that we trust will be fully realized.

Case I.—Mr. C. D. E., railway inspector, thirty-nine years old, was referred to me by Dr. J. T. Nix, Jr., in May, 1913, for bloody urine, frequency, tenesmus and pain in lower mid-back which had extended over a period of four years.

Cystoscopy showed a vesical growth involving entire right side of bladder, right trigonal area and arching half way over anterior wall. Examination was accompanied by so much pain and hemorrhage that limits of growth could not be defined. It was believed that tumor involved entire right half of bladder. Tumor was red, sessile in character, bleeding easily upon touch—typically a carcinomata. Ureteral ostia could not be seen, due to tumor mass and to the dark red, cumulus appearance of the trigonal mucosa. Capacity of bladder 75 c.c.

Urine showed heavy trace of albumin, no sugar, trace of indican, no diacetic acid or acetone, no casts, many calcium oxalate and triple phosphate crystals, few uric acid crystals, many epithelial cells, few blood-cells, abundant pus, and many Gram-positive cocci. Wassermann reaction, reported by Dr. C. C. Bass, weakly positive.

General examination showed nothing of note. Prostate slightly enlarged, boggy to the feel and a distinctly indurated area could be palpated in right lobe. Seminal vesicles apparently normal. Urethra admitted a 24 F. sound easily.

Potassium iodide internally, and mercury by needle intramuscularly, were given over a period of one month because of the faint suspicion

of syphilis. No improvement whatever occurred. Daily vesical irrigations had also been given during this time.

Suprapubic cystotomy under ether anæsthesia was now done, growth demonstrated to originate from right lateral vesical wall, sessile, about the size of a lime and so adherent to prostate and neighboring structures that resection was considered impossible. A section was taken for the pathologist, the tumor then treated palliatively by paquelinization with actual cautery, destroying as much of the vesical growth as thought expedient, a Pezzer catheter was then put into bladder suprapubically and bladder wall sutured around catheter. Pathologist reported that section showed carcinomata.

A few weeks after operation cystoscopy was done, introducing instrument through suprapubic opening and, noting that growth continued active, two applications of the Oudin high-frequency current were given without any effect on the tumors whatever.

Patient became dissatisfied and consulted another surgeon, who performed an exploratory suprapubic cystotomy, at which he affirmed my diagnosis of inoperable condition in bladder. A right-sided nephrectomy was done by this surgeon later for pyonephrosis. Patient died nine months after my last seeing him, immediate cause of death being exhaustion and sepsis.

Diagnosis.—Carcinoma of bladder with metastasis to prostate.

Case II.—Mrs. A. O'C., housewife, fifty years old, was referred to me by Dr. W. A. Gillaspie, in November, 1913, for cystoscopy because of patient voiding bloody urine—a condition existent for one month. Patient had experienced only one similar attack of bleeding four years previous, first attack lasting only three days.

Cystoscopy revealing a " chain " of seven small, white papillomata of bladder extending across the viscus behind the left ureteric ostium and parallel to the interureteric bar; none of these tumors were larger than a split pea. Directly on central spot in trigone was a white villous papilloma about the size of a china-ball. It was from the largest tumor in the " chain " group mentioned from which the blood was seen to spurt. Ureteral ostia normal and easily catheterized, revealing normal urine from both kidneys. Bladder mucosa congested in spots on trigone; otherwise normal. Mixed (bladder) urine from catheterized specimen also normal. Wassermann negative, reported by Dr. W. H. Harris. General examination negative.

Three high-frequency cauterizations with Oudin spark in all were required to destroy tumors. The bleeding was arrested with first application of spark. Treatments were given at weekly intervals. Subsequent history uneventful. Cystoscopy in April, 1915, showed no recurrence. No material was obtained for microscopic study, but clinically these tumors were benign papillomata.

Apart from the value of high frequency in this case, an interesting feature to the writer was the length of time which had elapsed (four years) between the first appearance of blood in the urine and the cystoscopy, in that at this examination the tumors found were comparatively small. Was the attack of bleeding four years previous due to these same tumors? If so, these tumors had grown very little, or very slowly, in four years.

Diagnosis.—Multiple (8) benign papillomata of bladder.

CASE III.—Mrs. M. W. W., housewife, forty-five years old, was referred to me by Dr. C. W. Allen, in March, 1914, because of "hemorrhage from bladder" which would not respond to the usual treatment. Hæmaturia had been present for two months. No pain or frequency.

Cystoscopy performed during a severe attack of bleeding was unsatisfactory because the bladder could not be washed free of blood-tinged media, and many adherent clots on trigone could not be dislodged, obstructing view of ureteral orifices. Adrenalin used locally to aid in controlling hemorrhage. Bladder capacity 200 c.c. A tumor mass in region of right ureteral ostium, about size of a chestnut, was finally seen with its surface apparently villous in appearance. As all attempts to stop hemorrhage by the local procedures usually employed in such cases proved futile, as there was no high-frequency apparatus in the infirmary at which patient was confined, and as patient was beginning to show signs of exsanguination, suprapubic exposure was decided upon as a life-saving measure. Wassermann reported by Dr. J. A. Lanford as negative.

Under ether narcosis Dr. C. W. Allen, assisted by the writer, performed a transperitoneal cystotomy, this route being chosen by the operator so that a thorough examination could be made of all perivesical structures. Bladder opened in the median line and immediately a large quantity of coffee-colored urine admixed with clots was expelled through the incision. After aspirating bladder contents and viscus sponged dry, a single, large papilloma about the size of a lemon was seen to arise from the right lateral wall, behind and external to the right ureter ostium. Tumor was suspended by a pedicle about the size of a small lead pencil. A profuse bloody ooze was seen to be coming from the base of the tumor. Pedicle clamped with two Ochsner clamps, tumor cut away with scalpel and base thoroughly cauterized with Paquelin cautery. Peritoneum closed; the two clamps were left on tumor base to control hemorrhage; several sutures put into bladder wall around clamps; fascia sutured; large rubber-tubing drain being left in bladder suprapubically; muscles approximated and skin only partially closed with silkworm-gut around tube and clamps. Forty-eight hours later clamps were removed. There was no further hemorrhage. Pathologist reported tumor to be a papillary carcinoma.

Subjectively, patient was greatly improved following recovery from operation, but cystoscopy showed that tumor base was "unhealthy" in appearance—resembling recurrence. Five high-frequency cauterizations with Oudin spark to base failed to show any improvement whatever. Patient left for her home in Mississippi.

In October, 1914, seven months after first operation, Dr. Allen, assisted by the writer, again did a median section over original scar. Bladder interior now found smooth, clean and in an apparently healing stage at site of original operation. However, in dissecting out the right ureter near the bladder it was found to be thickened and enlarged to the size of an adult thumb, hard to the feel in some portions, while boggy in other parts. The tumor base as well as the lower third of the right ureter was considered by us still malignant. Right ureter was ligated

and cut five inches above its insertion into bladder, and this, with that portion of the bladder wall including right ureteral ostium and the tumor base, was resected *en masse* through all coats of vesical wall and including one and one-half inches of healthy bladder wall surrounding tumor site, so as to be reasonably sure of getting rid of the cancerous infiltration. To accomplish this the right broad ligament was severed and at the same time the right ovary was removed. Peritoneum, fat and muscles brought together with catgut and skin closed with silkworm; cigarette drain being left suprapubically down to bladder and a rubber drain placed through stab wound in vagina to drain abdominal cavity. Pathologist reported tumor-base cicatrix and entire portion of ureter removed to be carcinomatous. This second operation, as the first, was done under ether anæsthesia.

A third operation, eleven days after the second, under local (novocain) anæsthesia was done by Dr. Allen. This was for right-sided nephrectomy. Right kidney proved to be a mere shell—hydronephrosis produced by the carcinomatous ureter on that side, the growth having totally occluded the ureteral lumen. No evidences of malignancy were demonstrated microscopically from sections made from this kidney. Recovery uneventful.

An intravenous phthalein test made two months after last operation to determine status of remaining (left) kidney showed an output of 42 per cent. for two hours. Cystoscopy at this time showed no evidences of recurrence of tumor growth in bladder. Patient has gained thirty pounds in weight and felt fine. Urine showed a trace of albumin, a few pus-cells, and a few Gram-positive cocci.

Since last operation patient reported once every three months for cystoscopy. No further recurrence was noted until September, 1916, nearly two years after last operation, when, at cystoscopy, a small papilloma about the size of a small china-ball was seen to be located in the suprapubic scar, located in the *bas fond*. Two high-frequency cauterizations with Oudin spark thoroughly destroyed this little tumor. The last cystoscopy done in January, 1917, shows bladder free from growth and patient in perfect health.

Diagnosis.—Papillary carcinoma of bladder and right ureter. Right-sided hydronephrosis, secondary.

CASE IV.—Mr. R. B., street-railway conductor, twenty-five years old, came to me in March, 1914, for bloody urine which had been present for six weeks; no pain or frequency.

Cystoscopy showed a single white villous papilloma about the size of a marble situated to inner side and a little behind the right ureteric ostium. The blood was seen to come from the pedicle of the tumor. Rest of bladder normal. Mixed (bladder) urine normal except for excess of blood-cells. Both separate kidney urines normal. Wassermann negative. Phthalein intravenously gave 78 per cent. for two hours. General examination negative.

Two high-frequency cauterizations with Oudin spark, using one-quarter inch spark-gap, completely destroyed the tumor. Bleeding stopped with first application of current. No sections obtainable.

Last observation in February, 1916, nearly two years after treatment, shows bladder still free from growth.

Diagnosis.—Benign papilloma of bladder (clinically).

CASE V.—Mr. J. L., cooper, sixty-three years old, was referred to me by Dr. M. E. Brown, in June, 1914, because of bloody urine, frequency and pains in urethra and in left side, extending over a period of seven months.

According to patient, he fell from a trestle to the ground (a distance of about ten feet) seven months ago, striking his left side on a projecting piece of timber. Immediately following this accident suffered greatly with pain in left side, began voiding bloody urine and noted that he had to empty bladder frequently. Hæmaturia has continued with few intermissions ever since. Of late has severe pains in urethra during urinations. The patient's history led us to suspect trouble confined to left kidney. Prostate not enlarged, but an induration was felt on left side in region of left seminal vesicle, induration probably in bladder wall.

Physical examination elicited nothing of note. Kidneys not palpable and no tenderness of renal areas; pressure over suprapubic region, however, produced some pain, but nothing could be palpated through abdominal wall. Wassermann negative.

Cystoscopy revealed a sessile tumor in *bas-fond* about the size of a silver dollar, flat, and bleeding from several points. Several grayish blood clots were attached to the tumor. Ureteric ostia could not be recognized due to intense trigonitis.

Repeated high-frequency cauterizations with Oudin spark to arrest the hemorrhage were only partially successful, due to the fact that bleeding was usually so profuse that cystoscopic manipulations were not very satisfactory. Repeated intradermic and intravenous injections of 0.65 gm. doses of coagulose failed to check the hemorrhages.

An 18 F. soft rubber catheter was placed in urethra to drain bladder continuously—a retention catheter. Bleeding stopped for a few days, but only to return more profusely than ever. Patient in bed all the time.

Under ether anæsthesia the writer performed a suprapubic cystotomy, bladder thoroughly inspected, cystoscopic diagnosis confirmed, a small section removed from tumor aseptically, tumor thoroughly cauterized with Paquelin cautery and bladder closed around a Pezzer catheter, which was left to drain off the urine suprapubically. Hæmaturia never remitted sufficiently to do a phthalein test. Pathologist reported carcinomata.

Within a month after his admission to hospital a definite metastatic infiltration to left lobe of prostate could be felt. Patient became gradually weaker, morphia or pantopon had to be given continuously for pain, and patient succumbed to exhaustion and general sepsis exactly one year after coming under my observation. Due to general condition of patient and to the extent of the cancerous process the case was considered inoperable from the start and the suprapubic paquelinization and drainage were done only to make patient more comfortable. In this we succeeded.

Diagnosis.—Carcinoma of bladder with metastasis to prostate.

CASE VI.—Mr. V. C., engineer, forty-nine years old, was referred to me by Dr. E. L. King, in July, 1914, for bloody urine, frequency

and pains over lower mid-back and suprapubic region which had been existent for two years. Impairment in stream for one year also.

Cystoscopy demonstrated a papilloma occupying area of left ureteric orifice about size of a chestnut, three small papillomata on left lateral margin of trigone and many (number undetermined) villous-like projections encircling inferior aspect of internal vesical sphincter. Right ureter ostium easily recognized; left ostium obstructed by the growth. No sections of tumors obtained.

Examination showed a poorly developed and nourished white male. Nothing of note was found upon physical examination. Prostate negative; seminal vesicles not palpable. Wassermann, by Dr. W. H. Harris, negative. Urine showed a heavy trace albumin, no sugar, many epithelial cells, excess of red blood-cells and leucocytes in proportion to the blood present; no organisms. Phthalein test not made on account of excessive bleeding.

Eight high-frequency cauterizations in all were required (with Oudin spark) to destroy all the tumors. Bleeding ceased with first treatment. Treatments were given at five-day intervals.

Patient has reported at three-month intervals for cystoscopy. Last examination in January, 1917, shows bladder still free from growths.

Diagnosis.—Multiple benign papillomata of bladder (clinically).

CASE VII.—Mrs. G. C., housewife, fifty-three years old, was referred to me by Dr. J. T. Nix, Jr., in January, 1915, for bloody urine and frequency which had existed, intermittently, over a period of two years.

Cystoscopy under novocain anæsthesia demonstrated a "bald" sessile tumor about the size of a walnut, located on right lateral vesical wall behind and to the outer side of the spot where right ureteral ostium is normally located. Multiple ulcerations with shreds or "tags" of sloughing mucosa appeared upon surface of tumor—some of these areas bleeding freely upon touch. Surrounding tumors was an area of œdema bullosum. Rest of bladder of a deep red, dull, cumulus appearance—the picture of a severe grade of chronic cystitis. Ureters could not be seen.

Patient was a very corpulent female, of a highly "neurotic" temperament. It was only after much persistence on the part of her physician that she consented to a cystoscopy. Rectal palpation negative.

Urine was negative except for a few pus-cells, many Gram-negative bacilli, few Gram-positive streptococci and tumor particles. Wassermann was negative. No examination of tumor made microscopically, but no doubt existed in my mind other than that tumor was malignant. She refused operation, even refused a trial treatment with Oudin spark. This case did not report back after first cystoscopy and has since been lost sight of.

Diagnosis.—Carcinoma of the bladder (clinically).

CASE VIII.—Mrs. M. J. R., housewife, sixty-two years old, referred by Dr. E. B. Liddle, in April, 1915, for bloody urine, frequency, and pains across lower mid-back, over bladder and in her sides, which had persisted for two years.

Cystoscopy showed a cluster of four papillomata arising from left

lateral wall of bladder behind and above left ureteral orifice; multiple villous-like projections also encircled internal vesical sphincter. Ureteral ostia normal.

General examination demonstrated nothing noteworthy. Patient said she had lost twenty-five pounds in past four months. Urine showed trace of albumin, no sugar, many epithelial cells, many blood-cells, few pus-cells, fair number of Gram-negative bacilli.

Nine high-frequency cauterizations in all were given with Oudin spark. Bleeding stopped with first application of the current. It was found that the tumors about the left ureteral orifice had been totally destroyed, but those at the internal vesical sphincter were still present and it was almost impossible to get the electrode-catheter in such a position as to apply the spark satisfactorily. Patient went to her home in Mississippi for a rest and was asked to report back in three months.

Upon her return it was found that a recurrence of the tumors on left lateral wall had occurred. Two small papillomata were easily destroyed at one sitting.

As the high frequency was now considered inadequate for handling tumors involving internal sphincter, suprapubic cystotomy and paquelinization was decided upon as the best means of removing these tumors. Accordingly, under ether anæsthesia, Dr. J. Hume, assisted by Dr. S. Logan and the writer, exposed the interior of the bladder, demonstrated a single large papilloma the size of a walnut, arising from the left lateral aspect of the vesical sphincter, its base extending into the urethra. Tumor was clamped, removed and base freely cauterized with Paquelin cautery. Three small tumors on trigone were also destroyed in this way. Pezzer catheter left in *per urethram* and bladder closed with three rows of sutures. Recovery uneventful. This was in October, 1915. Patient has not yet reported back for cystoscopy, but in a letter received recently she states that she has enjoyed perfect health. Tumor submitted to pathologist and was reported as benign papillomata by Dr. H. W. Wade.

Diagnosis.—Benign papillomata of bladder.

CASE IX.—Mr. H. L., farmer, forty-four years old, seen in conjunction with Dr. J. Hume and Dr. S. Logan, came to us for bloody urine, frequency and tenesmus which had existed intermittently over a period of four years.

Cystoscopy demonstrated, in the region above and behind the right ureteral ostium, several papillomatous growths; and in the same vicinity were several growths which I considered "bald" or malignant. Tumors bled profusely from several points. The exact number of tumors was not determined.

Patient was first treated in our service by Dr. S. Logan with high-frequency cauterizations by means of Oudin spark, with only fair results. The writer also administered many of these treatments and the results were anything but encouraging. However, the bleeding had stopped and patient left the hospital and has since been lost sight of.

Diagnosis.—Carcinoma of bladder (clinically).

CASE X.—Mr. J. M. J., painter, sixty-six years old, referred by Dr. C. W. Allen, in June, 1915, for bloody urine, slight frequency and pain

in lower abdomen following hard work. This condition had existed for three years.

Cystoscopy, performed after urethral dilatation with sounds because of a stricture at bulbo-membranous juncture, showed three papillomatous tumors and several apparently "bald" tumors involving the whole left side of bladder, including left ureteral ostium. The sessile tumors were ulcerated and bleeding in spots. Left ureter ostium not seen; right easily recognized. Entire bladder mucosa deep red, dull and covered with flakes of pus.

Patient would consent neither to operation nor to a trial treatment with the Oudin high-frequency spark. I had an opportunity of seeing patient only once—at the cystoscopy. Temperature was 102° F. Felt chilly. Had lost fifteen pounds in past year. Urine contained much pus, red blood-cells and many Gram-positive cocci. Some particles of the tumors obtained in bladder washings at the cystoscopy were submitted to pathologist. Dr. H. W. Wade reported papillary carcinomata. Prostate was soft, regular, not painful, not enlarged.

Diagnosis.—Multiple papillary carcinomata of bladder.

CASE XI.—Mr. A. A., Confederate veteran, seventy-three years old, seen in June, 1915, in conjunction with Dr. J. Hume and Dr. S. Logan, came to us for acute retention. For five weeks had been voiding bloody urine and pain in left lower quadrant of abdomen has also been present during this time. Urinary frequency for years.

As the case was urgent no cystoscopy was done. No instrument that could be passed into the bladder *per urethram* gave any relief from the vesical distention due to the thick blood-clots which filled the bladder. The Young clot evacuator was tried, but without result. Suprapubic cystotomy was then decided upon. Under local (novocain) anæsthesia I opened the bladder in the usual manner suprapubically. Bladder was emptied of clots and the Walker retractors inserted so as to inspect inside of viscus thoroughly. Entire left side of bladder and vesical sphincter was found involved in tumor-growth; papillomatous in appearance in some areas while distinctly malignant ("bald"—sessile) in appearance in other areas. Pieces of the tumor were sectioned for pathologist. Neither ureteric ostium seen, but it was thought that only left one was involved in the growth. Tumor mass now thoroughly cauterized as well as possible with Paquelin cautery and Pezzer catheter put in bladder for permanent drainage; bladder wall, muscles and skin closed around catheter. Dr. C. W. Duval reported papillary carcinomata.

This operation relieved patient for a time, the urine became clear to the eye. Patient left hospital two weeks after cystotomy, it being impressed upon him, however, that he should report monthly and that he would have to wear the suprapubic drainage catheter always. Patient was lost sight of for four months. He then returned to hospital in practically a dying condition with a return of the acute urinary retention, he having removed his Pezzer catheter some weeks previously. Under general anæsthesia given by Dr. E. L. King, Dr. Joseph Hume, assisted by the writer, did a second suprapubic cystotomy, the internal vesical sphincter, trigone and left side of bladder con-

taining growth cauterized with Paquelin cautery and large rubber tube put into suprapubic wound for drainage. Death followed within two days, immediate cause of death being surgical shock.

Diagnosis.—Papillary carcinoma of bladder.

CASE XII.—Mr. J. J. D., book-keeper, sixty-two years old, referred by Dr. D. L. Watson, in July, 1915, for bloody urine and pain over bladder region and in mid-lower part of back. This condition had been present for seven months.

Cystoscope introduced with difficulty, due to obstruction at internal vesical sphincter, and causing much pain and bleeding. Bladder markedly trabeculated; right lobe prostatic projection marked, right ureteric ostium normal—left one not seen. Covering entire left lateral, superior and trigonal regions of bladder was seen a tumor mass, ulcerated, necrotic in spots, bleeding from other points. At times filaments of growth dropped over cystoscopic lens, totally obstructing view. Bladder capacity 150 c.c.

General examination showed nothing of note. Prostate *per rectum* not enlarged, soft, regular, not tender; seminal vesicles not palpable. Base of bladder by rectal feel gave no definite evidences of infiltration.

All surgical aid was refused by patient. Also refused Oudin cauterization. Patient was lost sight of, but Dr. Watson has kindly reported to me that in March, 1916, eight months after my seeing case, patient died—most probably from metastases from vesical carcinomata.

Diagnosis.—Carcinoma of bladder (clinically).

CASE XIII.—Mr. L. M., sixty-eight years old, photographer, seen in August, 1915, in conjunction with Dr. J. Hume and Dr. S. Logan, complaining of urinary frequency, bloody urine and tenesmus; no pain. This condition has been present for six months.

Cystoscopy revealed an extensive papillomatous tumor covering entire left lateral wall of bladder; brownish in color due to blood; area of tumor including left ureteral orifice. Right ostium easily seen and normal. Entire bladder interior congested. Capacity 250 c.c. Blood seemed to be coming from a portion of the growth just at the left lateral aspect of internal vesical sphincter.

Urine showed heavy trace albumin, no sugar, few epithelia, blood in excess, fair amount of pus, many fine Gram-positive bacilli, cocci and streptococci. General examination negative. Prostate normal. Wassermann negative.

Three high-frequency treatments with Oudin spark thoroughly destroyed this tumor. During treatments patient developed a marked alkaline cystitis; he was given bladder instillations of a sugar-water mixture of Bulgarian lactic acid bacilli and the cystitis promptly responded to this treatment. Last cystoscopy, in April, 1916, eight months after treatment, shows bladder still free of growth. Sections from bladder washings reported at the time by Dr. M. J. Couret to be benign papillomata.

Diagnosis.—Benign papillomata of bladder.

CASE XIV.—Mrs. M. E., sixty-five years old, referred by Dr. C. W. Allen, in February, 1916, for bloody urine, frequency, burning and pain over bladder region. Condition existent, intermittently, for past twelve years.

Cystoscopy revealed a sessile tumor about the size of a silver quarter-dollar, covering entire left half of trigone and left ureteric region, bleeding in spots. Markedly contracted bladder, holding 50 c.c. fluid, mucosa dark red and dull, with adherent flakes of pus in spots. Ureteric ostia not seen.

Urine showed heavy albumin, no sugar, few epithelia, few red blood-cells, much pus and Gram-negative bacilli. General examination negative. Wassermann negative. Intravenous phthalein test showed 16 per cent. in two hours.

Under novocain anæsthesia, Dr. C. W. Allen, assisted by the writer, did suprapubic cystotomy, exposed a hard, infiltrated, sessile growth on trigone typically carcinoma. Bladder much contracted, about size of a lime, and was exposed with difficulty. Anæsthesia, however, was complete. Growth thoroughly cauterized with Paquelin cautery; bladder closed around an indwelling Pezzer catheter. Suprapubic wound packed with iodoform gauze; skin and muscles not sutured. Operation lasted thirty minutes. Due to the age and physical condition of patient it was not thought advisable to do more than this. No sections obtained for pathologist.

Patient did well for one month; was allowed to return to her home in Mississippi. Death occurred seven weeks after operation from exhaustion and cardiac failure, according to the report of her family physician.

Diagnosis.—Carcinoma of bladder (clinically).

Case XV.—Mr. G. W. H., farmer, aged sixty-three, consulted me in March, 1916, for constant pain in bladder, marked frequency and bloody urine. First hæmaturia attack fifteen years ago; this bleeding has persisted intermittently ever since.

Cystoscopy showed entire left lateral wall of bladder included in a sessile, ulcerating growth apparently arising from a point behind and above the left ureteral orifice. Tumor invades left half of trigone also. Ureteral ostia not seen. Prostatic margin irregular, but no marked intravesical projection.

Urine showed much pus and many Gram-negative bacilli; only an occasional red blood-cell. General examination negative except that left lobe of prostate, per rectum, felt much enlarged, smooth, stony-hard to the feel. Right lobe not involved apparently. Left seminal vesicle matted with prostatic lobe on same side and very hard. Right vesicle not palpable. Wassermann negative. Intravenous phthalein test showed 48 per cent. for two hours.

Under novocain anæsthesia suprapubic cystotomy was done and inside of bladder thoroughly inspected by aid of Masson retractor. An infiltrating growth about size of half-dollar was seen located behind and to the outer side of left ureteral orifice. Tumor involves all layers of bladder and includes prostate on that (left) side. As tumor was encroaching upon internal vesical sphincter, it was cauterized with Paquelin as thoroughly as possible; Pezzer catheter retained in suprapubic wound and incision closed by layers.

The patient was up and out of the hospital within two weeks, voiding freely, no blood or pain. This would have been a case where

radium might have helped, but none was available. He did well for six months, but due to recurrence and metastases, finally succumbed.

Diagnosis.—Carcinoma of bladder; carcinoma of prostate; carcinoma of seminal vesicles (clinically).

CASE XVI.—Mr. A. L., brakeman, forty-six years old, referred by Dr. F. J. Spellman, in March, 1916, for bloody urine, pain in bladder and frequency. Hæmaturia present for one year. Is now unable to void at all.

Cystoscope was introduced with difficulty due to strictured vesical neck. Prostatic margin irregular, but no intravesical projection. The left half of trigone, left lateral wall of bladder and left ureteral orifice region was occupied by a tumor mass, sessile in areas while papillomatous in other spots. Entire mass was undergoing degeneration. Bleeding seen to come from internal vesical sphincter region. Ureteric ostia not seen. Bladder capacity 125 c.c.

Physical examination negative except for prostate. Left lateral prostatic lobe much enlarged, stony, hard; the seminal vesicle on the left was involved in this process, being hard and enlarged also. Left lobe of prostate and left seminal vesicle normal to the feel. Urine showed heavy trace albumin, no sugar, few epithelia, excess of red blood-cells and pus, many Gram-positive diplococci. Intravenous phthalein 15 per cent. excreted in two hours. Wassermann negative.

Under novocain anæsthesia suprapubic cystotomy was done, tumor mass well cauterized with Paquelin and Pezzer catheter drainage established suprapubically. As prostate and vesicles were involved, and as patient was very weak physically, it was decided by all who saw him that this was the most that could be done at this late stage of the disease. From last reports he is still alive and comfortable.

Diagnosis.—Carcinoma of bladder; carcinoma of prostate secondary; carcinoma of seminal vesicles secondary (clinically).

CASE XVII.—Mr. A. S. A., journalist, aged fifty-six, referred by Dr. W. A. Love, in April, 1916, complained of frequency, burning, difficulty. No hæmaturia. Chronic constipation for one year. Frequency and difficulty present for fifteen years.

Cystoscopy, attempted upon two different occasions, was found impossible, due to the size of the prostate or the marked obstruction at the internal vesical sphincter.

Urine showed a trace of albumin, no sugar, few epithelia, no blood, much pus and many Gram-positive diplococci. Urine voided only in drops. General physical examination showed nothing of note. Per rectum, prostate was found to be the size of a grape-fruit and stony-hard. Seminal vesicles so matted in the process as to be indistinguishable from prostatic tumor. Beyond prostate a circular mass involves rectal lumen, leaving an opening in bowel hardly large enough to admit little finger. Wassermann negative. Phthalein intravenously read 59 per cent. for two hours.

Proctoscopy revealed an annular stricture in rectum, seen to be about four inches from sphincter of anus, very suspicious in appearance of malignancy of the bowel.

As his urinary stream shut down completely a few days after first

seeing him, patient was admitted to hospital and, as no instruments could be introduced by the urethra, suprapubic cystotomy was done under novocain anæsthesia, assisted by Dr. H. J. Lindner. Prostatic projection into bladder, small but stony-hard, covered with multiple small bosses or tubercles. Internal vesical sphincter contracted and completely involved in a sessile growth which had practically closed the vesical outlet. A clear view of all structures could not be obtained, due to the depth of the bladder and the straining by the patient. Growth at vesical neck thoroughly cauterized with Paquelin, bladder outlet reëstablished and an indwelling catheter placed in urethra. Pezzer put in suprapubically. Bladder closed. Left hospital within ten days; the urethral catheter had to be removed because of irritation. Suprapubic Pezzer remained, however. Has never been able to void satisfactorily, however, *per urethram*.

Dr. C. W. Allen was requested to see this case by me and he confirmed my diagnosis of malignancy of bladder, prostate and vesicles. The case had gone too far to attempt anything radical.

Three months after operation he was still comfortable with the suprapubic drainage and was having no trouble while at stool. He left for his home in San Francisco and has not been heard of since.

Diagnosis.—Carcinoma of bladder; carcinoma of prostate; carcinoma of seminal vesicles (clinically).

Case XVIII.—Mr. F. M., painter, aged fifty-eight, consulted me in June, 1916, for bloody urine, frequency and pain in bladder region during and after each urination, these symptoms having existed intermittently for two years past.

Cystoscopy showed entire right lateral wall of bladder, right trigonal area and right vertex region occupied by a large, sessile, ulcerated tumor with jagged edges, bleeding in spots. No villi seen. Left lateral lobe of prostate enlarged. Ureteral orifices could not be seen.

Urine showed heavy albumin, no sugar, many epithelia, no casts, excess of pus and red blood-cells, few Gram-negative bacilli. Wassermann negative. Intravenous phthalein for two hours gave 65 per cent. General examination revealed bad teeth, anæmic generally, kidneys not palpable, marked tenderness to pressure over suprapubic region but no mass felt, reflexes sluggish. Prostate and seminal vesicles soft and small; no evidences of malignancy. On right side above right seminal vesicle area the base of the bladder feels bulging and doughy, suggesting tumor within viscus.

Patient put to bed with indwelling urethral catheter tried, but catheter seemed to increase rather than to check bleeding. High-frequency cauterization attempted twice with Oudin current to control hemorrhage, but in this was only partially successful. Tumor was not in a position to treat satisfactorily by this method.

June 21, 1916, suprapubic cystotomy under ether anæsthesia. Bladder interior freely exposed by Masson bladder retractor. A large, sessile, " mushy," ulcerating tumor seen to spring from internal vesical sphincter, very fragile, and seems to extend into posterior urethra. Tumor thoroughly cauterized with Paquelin, including base. Pezzer catheter drainage instituted from above; bladder and suprapubic

wound closed around catheter. Several portions of the tumor submitted to Dr. M. Couret, pathologist, were reported to be carcinoma. Due to fact that growth involved entire trigone, that the patient was fifty-eight years old and very weak from loss of blood, it was deemed unwise to attempt resection or cystectomy.

Patient did well for a while, but mestastasis occurred in the suprapubic wound; he grew generally weaker and died July 11, 1916, almost three weeks after the operation, of exhaustion.

Diagnosis.—Carcinoma of the bladder.

CASE XIX.—Mr. J. H., saw-mill worker, aged sixty-seven, consulted me in June, 1916, for bloody urine, marked frequency, poor stream and burning, symptoms being present for only one month.

Cystoscopy revealed a tumor occupying entire right side bladder, right ureteric orifice; tumor, size of a walnut, " bald," small ulcerations noted over its surface. Several small diverticula seen in *bas-fond.* Entire bladder trabeculated. Left ureteral orifice normal in size and shape.

Urine showed trace albumin, no sugar, many epithelia, no casts, many pus and red blood-cells, many Gram-negative bacilli and Gram-positive cocci. Smear from urethra showed only pus cells. Smear from prostatic secretion showed much pus and Gram-positive cocci. Wassermann negative. General examination revealed a left inguinal hernia, prostate enlarged, firm, regular, no nodules or irregularities to suggest malignancy.

This case was clinically a carcinoma of the bladder, but it was suggested to patient that he try high-frequency cauterizations with Oudin spark to control hemorrhage and later submit to a suprapubic cystotomy. Patient refused to submit either to further cystoscopic treatments or operation and was lost sight of shortly afterwards.

Diagnosis.—Carcinoma of bladder (clinically).

CASE XX.—Mr. A. C., farmer, seventy years old, consulted me in July, 1916, for urinary frequency, burning and bloody urine, the symptoms being present intermittently for two years past.

Due to profuse hemorrhage, the excessive formation of clots in bladder and to weakened condition of patient cystoscopy was not attempted. Urine showed heavy albumin, no sugar, few epithelia, excess of red blood-cells, much pus and many Gram-positive cocci. Prostate hard, enlarged, painful, but no nodules.

One week after seeing patient, the hemorrhage still persisting, suprapubic cystotomy under ether anæsthesia was done and a large fungoid carcinoma of right side of bladder was seen, involving and adherent to the right portion of the prostate. Condition recognized as inoperable, Pezzer catheter retained as drainage from above and bladder closed. Tumor sections were removed and partial cauterization attempted. Pathologist reported carcinoma.

Patient left hospital one month after operation more comfortable with suprapubic drainage of bladder and was lost sight of.

Diagnosis.—Carcinoma of bladder involving prostate.

CASE XXI.—Mr. N. G., fisherman, aged seventy, seen in September, 1916, in conjunction with Dr. J. Hume and Dr. S. Logan, complained

of bloody urine, pain in left lower part of back and urinary frequency. Trouble present eleven months.

Cystoscopy showed entire left side of bladder, including ureteral orifice area and internal sphincter, involved in a tumor mass, smooth, sessile, and about the size of an egg; dark red to brown, not bleeding. Prostate not enlarged.

Urine showed trace albumin, no sugar, few epithelia, much pus and blood, many bacilli and cocci. No tubercle bacilli. Wassermann negative. X-ray examination of entire urinary tract negative. Intravenous phthalein for two hours gave 5 per cent.

Three high-frequency cauterizations with Oudin spark gave no results. Due to poor general condition operation was not advised. No radium was available. Patient sent home.

Diagnosis.—Carcinoma of bladder (clinically).

CASE XXII.— Mr. P. M. A., boiler-maker, thirty-nine years old, seen in conjunction with Dr. H. J. Lindner in September, 1916, with bloody urine, some frequency, and difficulty in urinating. Blood present for only three weeks.

Cystoscopy showed a smooth, round, "bald" tumor about size of a lime occupying right ureteral orifice region and right side of internal vesical sphincter; bleeding easily upon touch; in some spots papillomatous excrescences seen. A clot covered part of the tumor which could not be dislodged. Entire bladder dull, dark red with *bas fond* trabeculated. Right ureteral orifice not seen but left visible and normal.

Urine showed trace albumin, no sugar, few epithelia, much pus and blood, many cocci and bacilli. Wassermann negative. General examination negative. Prostate not enlarged, soft, regular, tender. Seminal vesicles not palpable. Nine high-frequency cauterizations with Oudin spark given tumor. Hemorrhage stopped for a time and then high-frequency had no more effect. Tumor apparently stimulated to further growth by Oudin spark.

Suprapubic cystotomy finally done under general anæsthesia and growth destroyed as well as practical by means of paquelinization. Growth found at operation to extend well into external vesical sphincter and involve entire vesical trigone. Large Freyer tube left in suprapubic opening because radium applications will be attempted through this opening. Patient's condition improved; hemorrhage stopped. Patient still under observation.

Diagnosis.—Carcinoma of bladder.

CASE XXIII.—Miss M. L., cook, aged fifty-six years, seen in conjunction with Dr. J. Hume and Dr. S. Logan, in December, 1916, complaining of frequency and bloody urine, the condition being present only five months.

Cystoscopy revealed a single papillomatous tumor on left lateral superior wall of bladder the size of a hazelnut with a very small pedicle. Rest of bladder including ureteral orifices normal. Kidney urines negative.

Urine showed trace albumin, no sugar, few epithelia, few red blood-cells, few pus cells and many Gram-negative bacilli. Wassermann negative. General examination negative. Piece of tumor reported by pathologist benign papilloma.

Tumor totally destroyed in three applications of high-frequency cautery by Oudin spark. Last cystoscopy April 15, 1917, shows no recurrence of growth, but entire left lateral trigonal area presents condition of bulbous œdema. Is this a sign of recurrence?

Diagnosis.—Benign papilloma of bladder.

Case XXIV.—Mr. J. C., elevator tender, aged forty-six years, seen in conjunction with Dr. J. Hume and Dr. S. Logan in December, 1916, suffering with pain in bladder, marked frequency and bloody urine, a condition present for one year.

Cystoscopy made by Dr. P. J. Gelpi revealed two tumors in right lateral portion of bladder, one on trigone behind right ureter and other to the right of internal sphincter. Both tumors were typically papillomata and were treated twice a week for a period of six months. Bleeding stopped after first application of Oudin spark. Both tumors were apparently destroyed by high-frequency current according to Beer. This occurred six months before patient was admitted to our service. Just before admittance to hospital Dr. Gelpi again cystoscoped patient and discovered that tumors now filled entire bladder, were sessile, and bleeding from many points.

Patient was so anæmic and emaciated upon entering hospital that nothing was done but to put patient to bed and indwelling catheter, 18 F., put in urethra so as to drain bladder. 50 c.c. foul, bloody urine drawn off. Bladder irrigated with warm weak silver solution daily. Wassermann negative.

Urine showed heavy albumin, no sugar, few epithelia, many red blood-cells, much pus, many Gram-positive cocci and Gram-negative bacilli. When urine cleared a phthalein was done intravenously and showed 2.5 per cent. for two hours.

Entire suprapubic region was markedly infiltrated with hard growth almost up to and under skin of abdomen. Prostate very large and stony-hard, left lateral lobe being larger than right. Seminal vesicles not palpable.

Patient died from exhaustion two weeks after entering hospital.

Diagnosis.—Carcinoma of bladder; malignant metastasis to prostate.

Case XXV.—Mr. J. H., fireman, aged forty-nine years, consulted me in January, 1917, for bloody urine, frequency, burning and urgency —all these symptoms present for only one month.

Cystoscopy showed entire left side of internal vesical sphincter involved in a white, papillomatous mass with areas of sloughing and bleeding in spots. Marked inflammation of entire bladder mucosa; ureteral orifices could not be seen. Cystoscope was introduced with some difficulty, there being a marked narrowing of the urethra, a bladder neck and posterior urethra juncture—probably malignant infiltration.

Urine showed trace albumin, no sugar, many epithelia, much pus and red blood-cells, many Gram-positive cocci and bacilli. Patient's teeth very bad; general examination otherwise negative. Wassermann negative.

An interesting phase of this case was that seven months before my cystoscoping him he had a prostatectomy performed. It is evident from what his physician told him that there was no tumor in the bladder at that time. But no pathological examination was made of prostate removed suprapubically. This gland was most probably malignant and in removing same malignant cells were implanted in the edges of the capsule with a resulting malignancy of the bladder.

Several high-frequency cauterizations were made to tumor with Oudin spark, but without effect except to check hemorrhage. The growth was seen to enlarge in size at every succeeding cystoscopy. Pieces of tissue were reported papillary carcinomata by pathologist.

Under ether anæsthesia suprapubic cystotomy was done and paquelinization of growth carried out as thoroughly as possible. Left ureteral orifice, entire trigone and internal vesical sphincter involved in growth. Growth practically occluding vesical outlet. Pezzer catheter put in from above for permanent drainage. Radium advised, but patient left city and has been lost sight of.

Diagnosis.—Papillary carcinoma of bladder probably secondary to malignancy of prostate.

Case XXVI.—Mr. I. A. G., barkeeper, aged fifty years, consulted me in January, 1917, for bloody urine, frequency and difficulty—a condition which had been present for one month. Thinks he has had a "stricture" for thirty years. Urinary stream poor for five years. No pains nor aches.

Cystoscopy shows a small papilloma to outer side right ureteral orifice and also multiple papillomata involving internal vesical sphincter. Bleeding comes from growths in bladder neck. Ureters easily seen and catheterized without trouble; both kidney urines sterile. Bladder mucosa otherwise normal. Pieces of tumor reported by pathologist benign papillomata.

Urine heavy albumin, no sugar, trace phosphates, few epithelia, much blood and pus, many Gram-positive cocci. Wassermann negative. X-ray of genito-urinary tract negative for stone. Teeth bad; general examination otherwise negative. Prostate moderately enlarged, soft, not nodular, smooth, not tender. Seminal vesicles not palpable.

One high-frequency cauterization with Oudin spark destroyed the tumor at the right ureteric ostium; several applications of spark to internal vesical sphincter failed to thoroughly destroy these growths due to their position. Following the advice of Beer in this type of case the bladder was therefore opened suprapubically under local (novocain) anæsthesia and with a Paquelin cautery the tumors were completely destroyed at the bladder neck and in posterior urethra. The Masson bladder retractor was of much benefit here in giving the operator a good exposure on vesical interior including internal sphincter region. Bladder closed without drainage. Recovery uneventful. Case still under observation.

Diagnosis.—Benign papillomata of bladder.

INGUINAL HERNIA IN THE MALE*

WITH REGARD TO POST-OPERATIVE SEQUELÆ

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With the aid of the excellent Follow-up System in operation on Dr. E. H. Pool's service at the New York Hospital, the writer has been enabled to make an intensive study of the after-results of operation in 148 cases of inguinal hernia in the male.

This series is a consecutive one of all the operations for inguinal hernia performed on the Second Surgical Division of the New York Hospital during the given period, except for the necessary exclusion of 13 patients of whom no trace could be obtained after leaving the hospital and the omission from present consideration of all cases in the female.

The last case in the series was operated over eight months ago, and the earlier ones have been followed for a year and a half.

Hydrocele of the tunica followed herniotomy in 20 cases, or 13.4 per cent., and attention may well be drawn to this sequela, about which very little has been written.

Bloodgood (*Johns Hopkins Hosp. Reports*, vol. vii), in speaking of the results following the old Halsted operation, with wide transplantation of the cord straight out through the aponeurosis, says that hydrocele occurred in 20 per cent. of the cases where venectomy was done with a view to reducing the size of the cord; but occurred in only 3 per cent. where the veins were not removed. He lays great stress upon not dividing all of the mesocord, or bed of the cord.

The natural inference from Bloodgood's observation is that venous stasis, following venectomy, is a cause of hydrocele; but with this inference we are not in entire accord, and for the following reasons:

1. In 30 consecutive venectomies for varicocele, only one case developed post-operative hydrocele.

2. In 78 cases of hydrocele, only 3 cases had coexistent varicocele, and 3 others were results of previous varicocele operations.

3. Venous stasis is much more frequent on the left side than upon the right, as evidenced by the greater frequency of varicocele on the left (over 90 per cent.); but hydrocele is not more frequent on the left than on the right, there being 39 of each kind in a series of 78 cases.

However, the relationship between hydrocele and inguinal hernia is a very real one and, to the writer, assumes the rôle of greatest interest in this study.

At once we are impelled to distinguish sharply between the two types of

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hernia, oblique and direct, for we find that it is the oblique hernia which is associated with hydrocele.

TABLE I

TABULATION OF 148 OPERATIONS FOR INGUINAL HERNIA

	Number of individuals	Number of operations	Age at operation	Right side	Left side	Bilateral	Operation for recurrence	With coexistent hydrocele
			years					
Oblique hernia.....	91	102	27.6	65	37	12	4	13
Direct hernia.....	29	46	36	24	22	17	5	0
Total.....	120	148	...	89	59	29	9	13

We have mentioned that in our series of 148 cases there developed 20 hydroceles as a sequela of the operation, 18 of these following oblique hernia, only 2 following direct hernia.

Is the hydrocele thus developed of any lasting importance or is it to be early and completely absorbed?

In 7 instances the hydrocele had entirely disappeared in less than three months, in 1 other case it disappeared between four and six months; nevertheless, we are confronted with 12 postoperative hydroceles which have persisted over six months without receding and which are probably permanent.

There are therefore 12 persistent hydroceles following 148 operations, or 8.1 per cent.; 10 of these followed 102 oblique herniæ or 10.2 per cent.; and 2 followed 46 direct herniæ, or 4.3 per cent.

If the assumption be true that hernia operations are a cause of persistent hydrocele, which fact is not commonly stated in treatises on hydrocele, then one should find this evidence upon reviewing a series of cases admitted for the relief of hydrocele (see Table II).

TABLE II

ETIOLOGY IN SIXTY CONSECUTIVE HYDROCELE OPERATIONS

13 cases followed herniotomy, from 1 to 10 years before.
13 cases were admitted with coexistent oblique herniæ.
0 cases were admitted with coexistent direct hernia.
3 cases followed operation for varicocele.
5 cases followed operation for inguinal adenitis.
1 case was recurrent after a hydrocele operation.
13 cases resulted from trauma or occurred spontaneously.
12 histories do not mention any previous operation, but neither do they exclude it.

60

Here we find that more than 21 per cent. of all hydroceles presenting for operation followed herniotomy on the same side, and that another 21 per cent. were found coexistent with oblique herniæ, but never with direct hernia.

The hydrocele is not merely a matter of venous stasis nor of the type of repair of the inguinal canal, for exactly similar conditions would exist after

operations for either oblique or direct hernia, if one uses the Bassini in both instances, but hydrocele is definitely a matter concerning the anatomical position and type of hernial sac and its operative treatment.

TYPES OF INGUINAL HERNIA

In our series (see Table I) oblique herniæ occurred twice more frequently than direct; 102 oblique, and 46 direct.

There were 12 operations for bilateral oblique hernia, but when we include those individuals in whom a previous operation had been performed upon the other side, or where there has been shown at the "Follow-up" that a hernia exists on the other side, we must add 7 individuals, making a total incidence of bilateral oblique hernia 19 times among 91 patients, or over 20 per cent.

In the series of 102 oblique operations there was a great preponderance of right side over left; 65 right, 37 left; for which we offer no explanation.

In 13 cases the sac was of the congenital type, and in 18 cases it was definitely described as of the funicular process type. There were a number of others in which the length and extreme narrowness of the sac strongly suggest the funicular type, although the operator did not so call them.

One may therefore conservatively state that more than one-third of the 102 oblique herniæ presented sacs of a developmental character, which lends weight to the claim of some writers that all oblique herniæ exist as potential sacs from birth.

The average age at operation for oblique hernia was 27.6 years. Of the 91 individuals, 30 were under twenty years of age, and among the latter there were 24 distinctly funicular or congenital sacs.

Whence it appears that more than three-quarters of all herniæ operated upon before the age of twenty years were of developmental type, which again favors the claim that oblique herniæ are developmental in origin.

Hydrocele of the cord, or tunica, or both, was found associated with oblique hernia in thirteen instances at operation, but in no instance associated with direct hernia.

Associated with 9 of these hydroceles, the hernial sac was of developmental type, 1 congenital, and 8 funicular process sacs.

There were 2 cases of hydrocele of the cord, 7 cases of hydrocele of the tunica, 4 cases of both cord and tunica.

Hydrocele of the cord represents imperfect closure of the funicular process and is probably always accompanied by a small potential hernial sac.

From our statistics we may conclude that the presence of hydrocele of either tunica or cord, on the same side as a hernia, will point to the diagnosis of oblique hernia of either the funicular or congenital type.

DIRECT HERNIA

These herniæ were more often bilateral than unilateral, 18 instances among 29 individuals, or 62 per cent.

The average age at operation was thirty-six years, and the youngest individual was aged twenty-three years; which is consonant with our belief that direct herniæ are acquired, and do not exist as potentialities from birth or else they would develop earlier in life.

Among explanations of the etiology of direct hernia, we may venture the following: Congenitally weak aponeurosis and lower abdominal muscles; narrow lower rectus; atony and relaxation of the lower abdominal muscles due to disease, malnutrition, or to faulty postural attitude in standing; but in many other cases the general nutrition and muscle tone are above reproach and it is in these latter cases that we find the increase of properitoneal fat which seems to have wedged its way forward through a vascular interstice in the transversalis fascia and to have been followed by the peritoneal sac, as occurs in epigastric hernia.

Hydrocele which we have seen is so often associated with oblique hernia was not found associated with any one of our 46 direct herniæ; and but 2 hydroceles developed following operation for direct hernia.

DIRECT-INDIRECT HERNIA

There were 10 instances where the sac was found to bulge on both sides of the deep epigastric vessels, thus forming combined, direct and indirect herniæ, also spoken of as double or " saddle-bag " herniæ.

These have been counted with the direct herniæ, of which type they seem to be modifications or lateral extensions.

Our reasons for so classifying them are the following:

(*a*) In all 10 of the cases the direct hernia constituted the major factor; the sac to the outer side of the epigastrics was usually described simply as a bulging.

(*b*) All 10 of the cases occurred in bilateral herniæ, including 3 individuals with bilateral direct-indirect hernia; 3 individuals with direct-indirect hernia on one side and with direct hernia on the other; one individual with direct-indirect hernia on one side but presenting a repaired hernia on the other side, of type unknown (presumably the same?).

(*c*) In no instance of the 10 was there found an oblique hernia on the one side and a direct-indirect on the other; in other words, they were found associated only with direct hernia and never with oblique.

(*d*) No hydroceles were encountered in association with the direct-indirect herniæ.

Hence we group the direct-indirect herniæ with the directs and not with the obliques, because of their many similarities to directs.

In the whole series of 148 cases we came upon no instance of a direct hernia upon one side and a true oblique on the other; and we conclude that when herniæ are bilateral, they are of the same general type on the two sides.

SEQUELÆ OF OPERATION

Post-operative Tumefactions in the Scrotum.—Throughout the entire series painstaking notes were made of the local condition as found on digital examination, both during the hospital residence of the patients and months later through the Follow-up examinations.

The bedside notes reveal 56 instances of demonstrable adventitious swellings immediately following operation; an incidence of 37.9 per cent. for the series.

These swellings were much more frequent following oblique hernia operations, 48 per cent.; whereas after direct operations there were 15.2 per cent.

Inasmuch as trauma of dissection and mechanical rearrangement of the scrotal tissues is the admitted cause of most of these swellings, it is easy to see why they occur more often after oblique than after direct operations, for except in the cases of very large direct hernia there is seldom necessary any dissection in the scrotum, or of the cord itself; for the direct sac does not involve the cord or tunica, nor in most cases does the sac enter the scrotum.

An attempt to classify these post-operative tumefactions is necessarily somewhat conjectural, but is based upon their location, consistency, and in nearly every case of hydrocele by transillumination and by needle aspiration.

The hydroceles when first observed, a few days after operation, were usually small collections of fluid which might readily have escaped the casual observer, but upon aspiration would yield from 20 to 60 c.c. of straw-colored fluid.

The veins referred to as thrombosed were palpable as discrete oval or knot-like indurations along the cord in cases where venectomy had been performed and the ligated stumps approximated.

Distention of veins in the cord above the testis was met with in cases after venectomy and in other cases where probaby the canal repair had caused some obstruction to the venous circulation; but all of these cases cleared up after a few weeks.

The *tunica* thickenings, so-called, followed operations on the tunica and existed for some months or permanently as palpable fibrous thickenings usually behind and above the testis, and are explained by the mechanical rearrangement of the tunic after the Andrews, Winkelmann and other hydrocele operations.

Hæmatomata varied in size from a walnut to a distention of the whole half of the scrotum, spreading in the loose connective tissue beneath the dartos. Resolution was usually quite complete within three months, but some permanent fibrosis was left in half of the cases.

The unidentified indurations of the cord and of the testis were probably results of œdema or extravasation following scrotal dissection; most of these resolved within a few months, but in one case where there had been imme-

diate and marked swelling of the testis (without fluid) the testis was found quite atrophied when examined a few months after operation.

TABLE III

POST-OPERATIVE TUMEFACTIONS

	Number of operations	Hydroceles	Thrombosed veins	Distended veins	Tunica thickening	Hematoma	Induration of cord	Induration of testis	Total number	Percentage
Oblique:	102									
Early	...	18	5	6	11	6	4	3	49	48
Persistent	...	10	4	0	4	3	2	0	23	22.5
Direct:	46									
Early	...	2	0	0	0	0	2	3	7	15.2
Persistent	...	2	0	0	0	0	1	1	4	8.7

N. B.: In obliques there were 4 instances where two different swellings were recognized in one case; thus 53 swellings in 49 cases.

Many of the tumefactions noted above are of little more than academic interest and may be considered merely as necessary concomitants of scrotal dissection, hydrocele operations, venectomy, and, in less than three months, more than half of them have entirely disappeared. Or even if they persist as some slight thickening along the cord or about the testis most of them give rise to no subjective symptoms.

Thus we may dismiss without further discussion the tumefactions classed above as hæmatoma, tunica thickenings, distended and thrombosed veins, and indeed most of the unidentified indurations of the testis and cord.

Nevertheless, we have remaining, as persistent to date, 12 hydroceles which are of much greater import.

To tabulate 48 per cent. of postoperative tumefactions following 102 oblique hernia operations seems rather startling until one considers that, as a rule, no one examines the scrotum after operation, unless there is so much trouble there that the patient complains.

Certainly at the New York Hospital, under the same Visiting and House Staff, the records of a series of consecutive hernia operations, immediately prior to the commencement of our study, mention only 5 per cent. of post-operative swellings, although careful bedside notes were made, describing the progress of the wound itself.

The application of some form of scrotal support by adhesive plaster strapping, adhesive plaster "bridge," triangular muslin perineal support (Keen), was the routine procedure immediately at the close of operation.

But in my experience no one of these devices is efficient in supporting the scrotum unless constantly watched; furthermore, I do not believe that the tumefactions result from mere dependency of the scrotum, and so question very much the prophylactic value of the routine employment of scrotal supports.

At any rate 48 per cent. developed swellings despite the supports.

POST-OPERATIVE HYDROCELES

A brief analysis of the 20 hydroceles which developed in our series of 148 operations shows that they occurred ten times following very large scrotal sacs which required much scrotal dissection; four times with congenital sacs; six times with funicular sacs.

Two factors then emerge in the etiology of hydrocele, to wit: Trauma to the tunica, in extensive dissection; the presence of congenital or of funicular hernial sacs.

As for funicular sacs, we are dealing with a developmental defect. These sacs are usually long, narrow, intimately inserted in the cord structures, with delicate walls, often presenting one or several constrictions or complete obliterations forming small hydroceles of the cord, and occasionally with tiny communications into the tunica.

With this peculiar anatomical structure, it is quite possible that when one dissects away the supposed apex of the sac one is really tearing across an imperfectly closed tube which may have communicated with the tunica, and this insult to the tunica may induce hydrocele, just as hydrocele results almost uniformly from attempts to reconstruct a tunica out of a congenital hernial sac.

In the 4 cases of our series where a new tunic was constructed out of a congenital sac, all developed hydroceles, 2 of which have persisted to the present time.

We agree entirely with Bloodgood that in all cases of congenital hernia the tunica should be excised, " for hydrocele follows in the majority of cases in which it is sutured to form a new tunica."

Following operations on the tunica, we found 4 hydroceles, after 4 reconstructions of the tunica; 1 hydrocele after 7 " bottle " operations (Andrews); 3 hydroceles after 6 Winkelmann partial excision and suture; 0 hydroceles after 5 von Bergman total excisions.

DEATHS

There were two deaths among the 120 individuals; one died on the twenty-third day after operation as the result of pneumonia and pleurisy; the other man died of pulmonary embolism on the eleventh day when he first got up from bed. At operation, his deep epigastric vessels had been ligated and divided.

RECURRENCES

Up to date there are recorded 9 definite recurrences in the series of 148 cases, or 6.08 per cent.; but the difference between oblique and direct recurrences is so striking that they must be considered separately.

After 102 operations for oblique hernia there are but two definite recurrences, or 2 per cent.

After 46 operations for direct hernia there are already 7 definite recurrences, or 15.2 per cent.

There are, however, reported 6 cases (3 direct and 3 oblique), in which

later examination shows some noticeable bulging or weakness or diffuse impulse, but without any definite recurrence. Whether these cases may later develop true recurrences, further observation alone will reveal.

Three of the true recurrent cases were noted before operation to have extremely poorly developed abdominal muscles; two others were operated upon for already recurrent hernia, and some other explanation might be adduced to explain each of the remaining cases.

Five of the nine recurrences have developed upon one side following the repair of bilateral herniæ (1 oblique and 4 direct).

It is of considerable interest to note that in four of these five cases, the side to recur was that side which had been first operated upon.

This may require a word of explanation concerning the technic of bilateral hernia operations on the Second Division of the New York Hospital—namely, that one side is operated upon and completed; next, the other side after a complete change of instruments and draping; thus making in reality two distinct operations.

The neck of the first hernial sac then has been transfixed high up and doubly ligated and the wound closed; now when the opposite side is operated it is quite possible that in the effort to close the sac high up, undue traction is exerted across the midline upon the recently ligated first sac and slipping of the ligature may take place.

This is no mere conjecture of the writer but is based upon actual experience and inspection during the simultaneous operations upon bilateral herniæ by the operator and an assistant, when it is very easy, especially in direct hernia, for one operator, by tugging on his sac, to exert much traction on the opposite sac.

In one instance in our series, upon opening the sac on the second side, free blood was seen in the peritoneal cavity, evidently coming from the opposite side, which was, of course, at once reopened and the ligature found to have slipped from the neck of the sac.

ATROPHY OF TESTIS

Atrophy of the testis as a result of hernial operations occurred twice; in one case it followed a large oblique hernia which developed a postoperative hydrocele and hæmatoma; the other case was a recurrent direct hernia with marked induration of the testis and cord following operation.

TYPES OF OPERATIONS

In the 148 operations in our series there were 129 Bassini operations, including 12 rectus transplantations; 13 Ferguson operations; 6 Halsted old operations with wide transplantation of the cord to lie beneath the subcutaneous tissue.

In 2 cases a Pfannenstiehl incision was used for bilateral herniæ.

In 6 cases the deep epigastric vessels were ligated and divided.

Appendectomy was added in quite a number of right-sided herniæ.

NON-DESCENDED TESTICLE

There were 4 such cases treated by the Bevan method, and at the end of from six to ten months we find 2 cases which are satisfactory in that the testis is well down in the scrotum; but in the other two cases the testis remains very high in the scrotum, just below the external ring.

CONCLUSIONS

1. That oblique herniæ are certainly in the majority of instances of developmental origin; they are more often unilateral, and right-sided; they are often associated with hydrocele of cord and of tunica; but recurrence is less frequent than with direct hernia.

2. That direct herniæ are acquired herniæ, are very frequently bilateral; are not associated with hydrocele; but are very prone to recurrence.

3. That in bilateral hernia the sacs on the two sides are nearly always of the same general type, obliques or directs.

4. Hydrocele of either tunica or cord, on the same side as a hernia, will point definitely to the diagnosis of oblique hernia, usually of either the congenital or of the funicular process types.

5. That persistent hydrocele is a common and important after result of oblique hernia operations.

In conclusion we wish to express our thanks to our colleagues on the Attending Staff, and to the members of the House Staff of the Second Surgical Division of the New York Hospital, for their very great assistance in recording data for this study.

FRACTURES OF THE OS CALCIS

A STUDY OF SEVENTY-TWO CASES

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The cases studied were treated in the wards of the surgical services of Bellevue Hospital from the year 1911 to 1915. Practically all the cases were among the working class of people as seen in a large city.

Fractures of the os calcis form from 2 to 4 per cent. of all fractures. Usually the condition was either overlooked or a mistake was made in the diagnosis until the injured foot and ankle was submitted to the X-ray. An increasing number of these fractures have been seen and reported upon since the absolute necessity of the X-ray has been realized in the diagnosis and the treatment of fractures.

The mechanics of fracture of the os calcis can be easily explained. The calcaneum forms with the cuboid an arch, which is part of the bony structure forming the arch of the foot. The anterior part of this arch is composed of the tarsal and metatarsal bones, and on account of the number of joints is extremely elastic. The os calcis is the base of the posterior pillar, and the structure of the os calcis is such that it gives the greatest carrying strength for its weight. A fall, the usual cause of injury to the os calcis, causes a breaking down of this arch, generally in the direction of the posterior pillar. This is due to the fact that the posterior pillar is more directly under the line of the body, is more rigid and less elastic, is shorter, and its arch has a longer arc. The very much denser astragalus on top of the calcaneum, articulating with two facets, an anterior internal concave and a posterior external convex, is usually driven into the calcaneum. The anterior facet of the astragalus, being convex and fitting into the concave facet of the calcaneum, acts as a wedge and from this point the fractures usually run. The posterior part of the calcaneum receiving most of the counter pressure is driven upwards and backwards. The fracture is usually impacted and comminuted. The pull of the strong calf muscles has influence in the displacement of the posterior fragment. If the crush is severe and the comminution is marked, the displacement is almost as marked laterally as posteriorly.

Fractures of the os calcis are fractures of adult life. The average age of the seventy-two cases was forty-one years. The youngest case was fourteen years and the oldest was seventy-three years. Since, the writer has seen two cases in children, younger than in these cases, one eleven and the other twelve years. These two cases were the only cases of fracture of the os calcis seen in an active children's surgical service in over a year and a half. Both of these cases were due to crushes. The rarity of the fracture in children is probably due to the elasticity of children's feet and that they

are formed of such a large proportion of cartilage. In dividing into the age periods, the fractures occurred as follows:

10 to 20 years	2	40 to 50 years	15
20 to 30 years	8	50 to 60 years	11
30 to 40 years	29	60 to 70 years	1
		70 to 80 years	2

The fractures occurred in a very marked preponderance in males over females, the proportion being 68 to 4. This is no doubt due to the fact that males through occupation are much more exposed to injuries.

The causes of the fractures were as follows:

(1) Falls. Sixty-three of the cases were due to falls. The distances varied from two feet to six stories. One case came down in a hoisting chair, as fast as the drum could unwind, for a distance of twenty-two stories, landing in a sitting position. The greater the distance fallen, caused as a rule the more marked fragmentation, although there were several cases in which a fall of only 4 to 5 feet caused considerable comminution. The highest fall in which a simple fissure fracture without displacement occurred, was forty feet. The cases over fifty years of age showed as a whole shorter distances travelled with more marked comminution of bone. In the two cases occurring over seventy years the falls were only two and three feet. The youngest of the cases, a boy of fourteen, fell only four feet.

(2) Crushes. Four cases were due to this injury. One case was, in which a large flagstone came down on the heel from behind, crushing the foot, extensively comminuting the os calcis. One case was run over by a wagon and two cases were run over by automobile trucks. One of the cases run over by an automobile truck had a simple detached fragment of the posterior part of the os calcis, and the other two were bad comminuted fractures.

(3) Two cases had the foot caught in the groove of tracks while running and the momentum caused a fracture by twisting. One of these was a simple fissure fracture of the upper surface down through the greater process, just anterior to the articular surface of the astragalus. The other case was a comminution of the body with very little displacement.

(4) One case was of undoubted muscular action, in which, while running for a car a sharp severe pain was felt in the back of the heel with immediate disability. This was a fracture of the posterior tuberosity with considerable upward displacement.

(5) One case was caught by the heel in a pulley, after slipping, while six stories in the air. He remained suspended by his heel for several minutes. This case was a fissure fracture of the superior surface just anterior to the anterior articular facet, with no evident displacement.

The right os calcis was fractured thirty-three times, the left os calcis thirty-one times, and both were fractured simultaneously eight times. All of the double fractures were due to falls. Six showed both os calci extensively comminuted. One case had a simple fissure fracture of the left

with comminution of the right, and the other case had simple fissure fracture of each os calcis with no evident displacement.

The os calcis was fractured at the same time with other bones in eleven cases. The other bones were as follows: lower end of fibula, three times; tibia alone once; metatarsals, the first, second and fifth, once; femur and humerus once; femur, tibia and humerus once; and with the scapula once. These were all due to falls with the exception of the one associated with fracture of the metatarsals and that was due to a crush by a flagstone.

An attempt was made to classify the cases according to the report of Cabot and Binnie, but it was found impracticable as there were too many cases that would be on the borderlines. However, Cabot and Binnie's classification may be here quoted as follows:

(1) Fractures of that part of the body lying behind a vertical plane through the middle of the body of the astragalus, and those cases may be subdivided into special groups.

(*a*) Cases with one large heel fragment.

(*b*) Cases with small heel fragment corresponding to the avulsion fractures of authors.

(*c*) Cases showing cracks and fissures but no actual separation of fragments.

(2) Those in which the force of the blow has been extended upon that portion of the os calcis lying between astragalus in front of the plane mentioned above, *i.e.*, the anterior half of the bone. These fractures are nearly always comminuted.

(3) Cases in which the whole os calcis is crushed and extensively comminuted.

Cotton stated that the attempt to classify the fractures of the os calcis is about as useful as classifying cracks in a walnut, after the nut-cracker is through with it. The heel-bone is mashed down and there are all sorts of lines to be found.

Lounsbury divided his cases into five classes as follows:

(1) Those through the concave facet beneath the convex facet of the astragalus.

(2) Vertical fractures from just in front of the tuberosity running beneath, to a point just behind the posterior border of the convex articulation, with displacement upwards of the posterior fragment.

(3) Tear fractures, usually of the tuberosity.

(4) Combination of two or more of these types.

(5) Compound fractures.

In attempting to classify the seventy-two cases studied, it was found impossible with any degree of certainty to place them in the different types, so the method was used as follows which would also divide the lines of treatment.

1. Simple fissure or linear fractures without any displacement.
2. Linear fractures with displacement.
3. Comminuted fractures with little displacement.
4. Comminuted fractures with marked displacement.

Simple fissure fractures occurred upon the superior surface usually under the convex surface of the astragalus, and the line of fracture runs usually downwards and backwards, varying in distance, but generally from one-third to one-half the depth of the bone. This type was seen fourteen times in the seventy-two cases, more often than was expected. All these cases were due to falls. Fissure fractures were seen more often in the falls of shorter distances. They are a cracking of the superior surface of the os calcis from the force of the much harder astragalus.

Linear fractures with displacement occurred in the posterior part of the bone as a rule, usually running down through the tuberosity with a flattening out of the curved-under border of the os calcis due to upward displacement of the posterior fragment. This type occurred ten times. Eight of these were due to falls, one of the other two was due to muscular action and the other was due to a crush. The fragment was impacted seven times and loose in three.

Comminuted fractures without marked displacement occurred seventeen times. These cases showed numerous irregular lines running through the bone, but the general outline of the os calcis remained about normal. The arch of the foot showed no marked flattening. All of these cases were due to falls.

Comminuted fractures with well-marked displacement of the fragments occurred thirty-nine times. The lines at times had a rather stellate appearance, radiating from the anterior upper surface. The posterior fragment, or fragments, were displaced backwards and upwards, the other fragments at times are impacted into each other or what is much more common, they are displaced laterally, that is outwards, and sometimes very markedly. The arch of which the os calcis forms the posterior pillar is flattened out.

The signs and symptoms of fracture of the os calcis are pain in the ankle and heel, with absolute inability to bear the weight of the body on the foot. The swelling is usually marked and is most pronounced under both malleoli. At times, usually in the comminuted cases, the distance from the malleoli to the ground looks shorter in the affected foot. The most marked points of tenderness are below the malleoli and over the heel. Ecchymosis is usually a little late in appearing. Contrary to the idea stated in text-books that crepitus is common, this sign was only made out in ten cases. Three of these were simple fractures of the posterior part of the os calcis with displacement, while the other cases were all comminuted ones. Motion is impaired at the ankle, more marked in lateral motion than in flexion and extension. In making a diagnosis of the type of fracture, it is practically impossible to do so without the use of the X-ray.

The treatment of these seventy-two cases fell into three groups: (1) Operative; (2) immobilization without any attempt at reduction; (3) immobilization with attempts at reduction.

Two of the cases were operated upon. One case with a linear fracture of the posterior part of the calcaneum with marked upward displacement of the posterior fragment was treated by nailing the fragment back through a posterior incision. The result was poor, the tendo Achillis sloughing, with subsequent disability following. The other case was one with a loose fragment of the posterior part of the os calcis with very marked upward displacement of the posterior fragment, which was sutured back with kangaroo tendon. The subsequent result as far as followed was very good. The majority of the cases, fifty-six in number, were treated by simple immobilization with either a circular plaster cast or a molded plaster splint. The foot was placed as a rule in a position at right angles, as far as possible, to the leg. The cases in which the os calcis was fractured alone, as a rule, were made ambulatory with crutches and discharged as soon as possible. Generally the cases were lost sight of, the casts being removed in the Out-patient Department or in some other clinic.

Of those cases treated by immobilization with attempts at reduction there were fourteen. All of these cases were treated by manipulation in an endeavor to loosen the displaced fragments, manual traction made upon the heel, and the leg and foot put up in a circular plaster with the foot in extension in an endeavor to relax the pull of the calf muscles.

An endeavor to trace the cases was very discouraging and the results obtained were so few, that no accurate conclusions could be drawn for a report on the subsequent results. A study of the cases gives no evidence that would lead one to believe that they would be any better than the late results of others. The results are generally poor. Cotton in a recent article shows that the end results in cases treated by the ordinary methods as a rule are rather discouraging. To this everyone who knows anything about fractures of the os calcis agrees.

Simple linear or fissure fractures of the upper surface, while being comparatively few, give the best results to treatment. They show so little displacement that simple immobilization with the foot extended to relax the tendo Achillis, is no doubt the treatment. The number of this type in this series is higher than usual. The cast should be left on for a period of four weeks and should be followed with a course of passive motion and massage for a period of three weeks or so longer. The weight should not be borne on the foot for at least six to seven weeks after the injury.

The cases in which there is a linear fracture, usually of the posterior part with upward and backward displacement of the posterior fragment, unless treated with a view of reducing the displacement, will give a more or less permanent disability. Manipulation with the patient under anæsthesia may release the impaction usually present, and putting the foot up in plaster with the foot extended to relax the pull of the calf muscles,

occasionally will correct the deformity and give a good result. Lounsbury stated that it had failed in every instance in which he had tried it. Cabot and Binnie, in order to pull the fragment down, passed a urethral sound above the os calcis inside the tendo Achillis, and making traction downwards reduced the displacement. Cotton recommends the same procedure, but uses a pair of ice-tongs instead of the urethral sound in order to get a better grip. Lounsbury after reduction cuts the tendo Achillis to prevent the pull of the calf muscles. During the reduction he had counter pressure made by an assistant by pulling upwards across the sole of the foot with a section of a gas pipe. He exaggerated the arch of the foot by pulling the toes and the heel together, and applied his plaster so that this elevation was maintained. Open operation with nailing of the fragments has given very poor results, and in the only case in which it was done, in the cases studied, it was followed by sloughing of what was thought to be the tendo Achillis. Lounsbury, in his discussion of nailing, gave his opinion that this is just what follows. In fractures of the extreme posterior part, the so-called tear fractures, operation with a suturing of the fragment back in place with kangaroo tendon suture, drilling both fragments in order to have a firm hold, is the only treatment. It may be necessary in some cases to cut the tendo Achillis in order to bring the fragment down.

Comminuted fractures without marked displacement do not give good results treated by the ordinary methods. Even if there is no evident marked alteration in the outline of the os calcis, there is always some slight flattening of the arch, and a broadening of the foot, and what is more important, adhesions in the calcaneo-astragalo joint. In some of these cases manipulations with overcorrection of the arch and immobilization may give a good result.

Comminution with well-marked displacement forms the larger number of these fractures. This is the type in which the results are usually bad. The lateral displacement is generally overlooked, and the amount can only be judged by a fluoroscope or an X-ray taken from behind—something that is rarely done. Cotton has laid down rules for this class of cases that might well be quoted.

1. Loosen up the fracture by manipulation.

2. Pull the heel down. He used to put a sound through from the side to in front of the heel-cord, and pull down; laterally an ice-tongs is used as easier to handle and affording a better grip.

3. Free the joint motion between astragalus and calcis.

4. Push in the displaced bone under the external malleolus; this narrows and shapes the whole bone. This is done by striking with a big mallet on the outer side of the foot; padding with felt to take the blow; supporting the inner side of the foot on a sandbag. This impacts and, owing to the fact that the outer plate is firm, the impaction is usually fairly solid.

5. Put the foot up in plaster, not at right angles but with the heel-cord slack, also direct pressure on the heel is to be avoided.

The after care of fractures of the os calcis is long and tedious. Massage and passive motion must be kept up and all attempts made to improve the lateral motion of the foot, for this being due to interference with the calcaneo-astragalo joint. Pain in the sole of the foot is a frequent late symptom and undoubtedly is due to a flattening of the arch of the foot. This may be relieved by proper filling arch supporter or properly applied pads. Pains in the heel or under the external malleolus are usually due to spurs of callus, and had best be treated by removal of the protrusions.

AN ANATOMICAL AND EXPERIMENTAL STUDY OF SACRAL ANÆSTHESIA

By James E. Thompson, F.R.C.S. (Eng.)
of Galveston, Texas

Sacral anæsthesia has become so firmly established in the surgical clinic of the John Sealy Hospital as one of the safest and most valuable means of producing local anæsthesia in the regions supplied by the sacral nerves, that it has passed completely beyond the experimental stage. It is used as a routine procedure in all operations on the anal canal and lower rectum, in perineal operations, in external urethrotomies, and in operations on the body of the penis. Also, when combined with local infiltration of the abdominal walls in cystotomies and suprapubic prostatectomies. We have been following pretty closely the method advised by Harris, of Chicago, and it is our custom to inject 30 c.c. of the solution into the sacral canal and give it sufficient time to diffuse along the space outside the dura mater where it bathes the peripheral nerves before they pass out through the intervertebral foramina. The quantity injected is 30 c.c., and the solution is made by dissolving three No. A tablets in 30 c.c. of distilled water and adding 10 drops of a 50 per cent. solution of calcium chloride. (The composition of the A tablets is novocaine, 0.125 Gm.; suprarenin, 0.000125 Gm.) As a rule one injection is sufficient, and at the expiration of half an hour anæsthesia is complete in the branches supplied by the sacral nerves. We have injected a second time not infrequently and have never failed after a second injection to secure perfect anæsthesia. The quantity of novocaine used has been considerable, as much as 0.750 Gm. having been introduced into the peridural space in the two injections. As far as our experience goes we have never seen evidence of toxic symptoms.

The period of onset, the area of distribution and the intensity of the anæsthesia show considerable variation. We have found that the region of the anus seems to lose its sensibility first, and that operations involving cutting and burning can be performed within ten or fifteen minutes after the injection has been made. The patient will often resent rough dilatation of the sphincter even though anæsthesia may be complete to the knife or cautery. We have not been able to establish any definite sequence in the order in which the sacral nerves are affected; although we believe that the effect is more rapid the nearer the nerve trunk lies to the bulk of the fluid injected. We have found that the greatest intensity of action is shown in the areas supplied by the sacral nerves from the second downward, but that it extends in many cases upward beyond the second sacral as high as the upper lumbar and lower dorsal nerves. In one case the injection was made at 10.17 A.M., and at 11.16 A.M. anæsthesia was complete below the level of the umbilicus, and was associated with loss of sensation and motion in both legs (see Chart, Fig. 3,

Case B). The regions supplied by the first lumbar and twelfth dorsal nerves are anæsthetized in a large proportion of cases, and sometimes the anæsthesia is deep enough to allow us to perform operations on the scrotum, inguinal region, dorsum of the penis, and the suprapubic region of the abdomen. We have, however, found that in women the clitoris and labia minora do not often

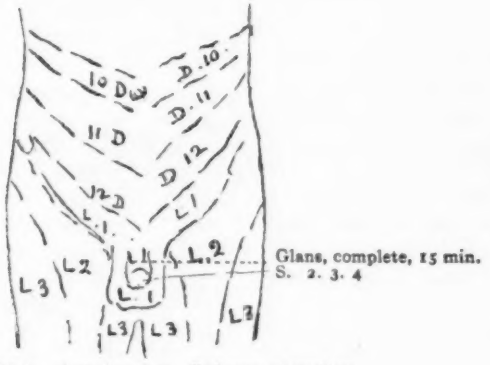


FIG. 1.—Male. Anterior view. Stricture of urethra.

lose their sensibility completely. In some cases of cancer of the cervix uteri the introduction of a large vaginal speculum has been painful, whereas extensive cauterization of the cervix and upper vaginal wall has been absolutely painless.

The appended charts, which were designed for our use by my colleague, Professor William Keiller, have been of great service in enabling us to show

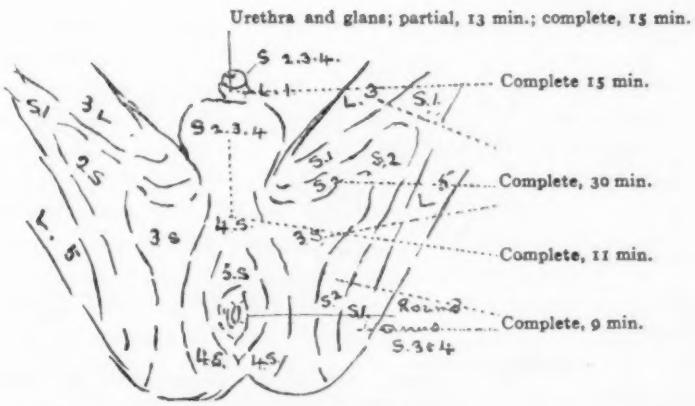


FIG. 2.—Male. Perineal view. Stricture of urethra.

in a graphic manner the area of anæsthesia, the time taken for the anæsthetic to produce its effect, and the spinal segments affected. Two pairs of these charts, one of a male (Figs. 1 and 2) and the other of a female (Figs. 3 and 4) are exhibited as types. On reflection it seemed probable that the anæsthetic effect was produced by the absorption of the drug into the peri-

pheral nerves outside the dura mater and that the intensity of the effect would be greatest in the nerves closest to the side of injection. This is evidently borne out by experience. The injecting needle seldom passes higher than the third sacral vertebra, and the bulk of the fluid is injected at this level, producing its maximum effect in the sacral nerves. A fair

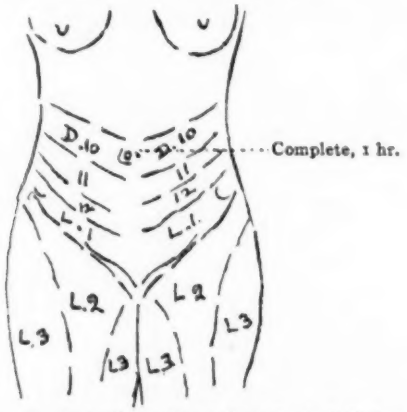


FIG. 3.—Female. Anterior view. Case B. Loss of sensation and motion in both legs. Complete loss of sensation as high as the umbilicus.

quantity of the fluid probably flows much higher and produces an anæsthetic effect on the upper sacral and lumbar nerves, and even on the thoracic nerves. This is of much less intensity, and in the majority of cases is rarely complete. In a few rare instances, however, we find sensation and motion lost in both legs and anæsthesia complete as high as the lower thoracic nerves.

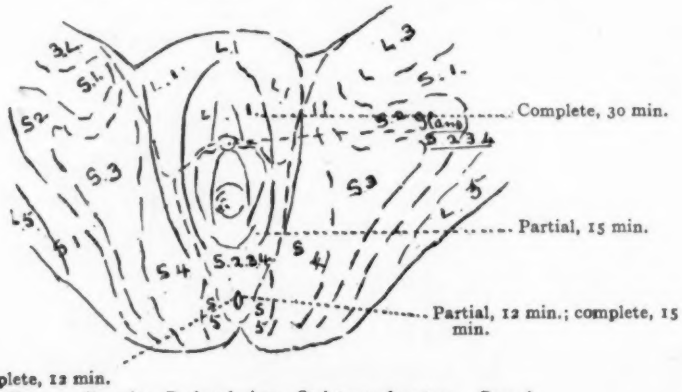


FIG. 4.—Female. Perineal view. Stricture of rectum. Case A.

The fluid evidently becomes diffused to a very high level, and we have been able to demonstrate this effectually on the cadaver. During the last winter, by the courtesy of Dr. William Keiller, I was allowed to follow the experiments upon cadavers used by the junior class in surgical anatomy. Fifteen bodies were used, and in each case 30 c.c. of aqueous solution of eosin was injected into the sacral canal. A needle 6 cm. long was used in each case. The dissection of the sacrum and spinal canal was made immediately,

and as soon as the data in this region were obtained the spinal canal and cord were exposed in the thoracic region opposite the spine of the scapula (third thoracic vertebra). Roughly speaking, in every case, in half an hour, the sacral and lumbar regions of the cord were exposed, and at the end of an hour the dorsal region was laid bare.

The appended table shows the anatomical findings:

Number of dissecting room table	Level of lower end of dura mater	Upper level reached by the staining fluid
3	Third sacral vertebra	Third thoracic vertebra.
26	Second sacral vertebra	Third thoracic vertebra.
7	Junction of second and third sacral	Seventh cervical vertebra.
9	Junction of second and third sacral	Sixth thoracic vertebra.
11	Second sacral	Third thoracic vertebra.
5	Third sacral (lower border)	Sixth thoracic vertebra.
15	Second sacral (lower border)	First sacral vertebra.
17	Junction of second and third sacral	Seventh cervical vertebra.
23	Second sacral (lower border)	Third thoracic vertebra.
19	Second sacral	Third thoracic vertebra.
20	?	Tenth thoracic vertebra.
13	Second sacral	Third thoracic vertebra.
1	Third sacral (upper border)	Third thoracic vertebra.
28	Junction of second and third sacral	Third thoracic vertebra.
Demonstration body	Third sacral	?

The following points may be emphasized:

1. In only one subject (cadaver No. 19) was there a failure to inject. This was caused by a curved sacrum and an unusually narrow and flattened canal. The peridural was eventually injected through a puncture in the lower lumbosacral region, and the data are given as if the sacral canal had been injected from below.

2. In every case, as a matter of routine, the dura mater was exposed above the third thoracic vertebra (the level of the spine of the scapula). Most of the students did not have time to expose the dura in the cervical region of the cord, but there is every probability that the staining went much higher than the third thoracic. In the two cases in which the dura was exposed at the level of the seventh cervical vertebra the outer surface of the dura was so deeply stained as to suggest staining at a much higher level.

3. In not a single body was any of the injection fluid found inside the dura mater. This means that the needle used slipped alongside the dura mater without puncturing it. This observation agrees absolutely with our clinical experience. We can only remember one clinical case in which the dura mater was penetrated by the needle. It appears from this that there is very little risk of intradural injection.

4. In the demonstration body it was noticed that while the injection was being made the eosin solution flowed out from both external iliac veins. This suggests that the needle had probably punctured a large vertebral vein and that the fluid was being forced directly into the systemic venous system. The possibility of repeating this in a living subject is suggestive.

5. In every case there was deep staining of both the anterior and posterior branches of the sacral nerves. The staining reached out far from the bone. As the sacral canal was exposed a few minutes after the injection the diffusion of the coloring matter along the nerve sheaths must have been a matter of a few minutes. It was interesting to notice that the diffusion of the coloring matter extended along all the nerve trunks. Thus the twelfth dorsal nerve was found deeply stained in most of the bodies, and in the cases in which the coloring matter had passed up to the cervical region in any intensity the posterior branches of the cervical and upper dorsal nerves also showed deep staining.

6. It appears justifiable to conclude that the coloring matter injected passed along the peridural space without any difficulty and travelled upward outside the dura mater. In its passage it bathed the peripheral nerves, and some of it passed outward along the lymphatic channels of the nerve trunks.

In not one case did any of the coloring matter gain entrance to the subarachnoid space. The cord and the roots of the nerves were unstained. The path along the peripheral nerves was evidently wide open in the cadavers, because in no instance was any excess of staining fluid found outside the dura mater.

It is, of course, unwise to assume that the paths taken by the staining solution are identical in the cadaver and in the living subject, but our clinical observations have supported the view that the diffusion of solutions of novocaine follows in the main the same paths taken by the stain in the dead-house observations. We have recorded a number of clinical cases in which sacral injections were accompanied by anæsthesia in the iliohypogastric, ilioinguinal and twelfth dorsal nerves.

By the courtesy of Dr. O. J. Potthast, demonstrator of anatomy in the University of Texas, I am able to insert data obtained from experiments performed on fifteen other cadavers dissected by the sophomore class. The following technic was employed. A needle 6.3 cm. long was used and 30 c.c. of an aqueous solution was injected into the sacral canal. The needle was thrust in as far as it would go and about one-third of the fluid injected. As the needle was gradually withdrawn the rest was injected. The sacral canal was opened immediately, but the spinal canal in the upper lumbar and dorsal region was not examined until ten days afterward. The following data were obtained:

In 2 of the bodies the injection had been made intradurally; in 11 the injection was extradural; in the remaining 2 the diffusion of the stain made accurate observation impossible. In both cases in which the subarachnoid space had been injected the stain had passed upward to the base of the brain. In 1 of the cases in which the injection was extradural the stain had passed as high as the attachment of the dura mater to the margin of the foramen magnum. In 2 cases it had extended as high as the cervical segment of the spine. In 1 case, in which the stain had not passed higher than the lower end of the dural sheath opposite the second sacral vertebra,

the stain had passed into the vertebral veins, which were found to be particularly large and dilated. In the other cases the stain extended on an average to the level of the ninth thoracic segments. The average distance of the lower end of the dura mater above the hiatus sacralis was about 5.8 cm. The shortest distance was 4 cm. (in this case the dura mater was punctured). The longest distance was 7 cm. The staining fluid entered the systemic veins in 2 cases. These observations were made immediately after the injection and not at the end of ten days.

A study of the sacral canal and of the hiatus sacralis was thought advisable in order to smooth out the mechanical difficulties of the operative technic. As a rule very little difficulty is met with clinically in passing the needle into the sacral canal. In a thin subject the bony margins of the hiatus sacralis can be felt distinctly. In fat people the bony landmarks are obscure, and a good plan is to introduce the needle about an inch higher up than the end of the sacrum, which can usually be felt plainly. In cases in which the coccyx is ankylosed with the sacrum an extra allowance must be made. The direction of the needle should be upward, exactly in the middle line, toward a point about 2 cm. deeper than the prominent spinous process of the first sacral vertebra. Some resistance will be felt as it penetrates the fibrous membrane closing the hiatus. After this is punctured the needle passes along the canal with ease. It is not necessary to introduce the needle farther than 3 or 4 cm., although our experiments and clinical experience prove that the risk of wounding the dura is very slight. If, however, cerebrospinal fluid escapes the needle should be withdrawn to a lower level until the fluid ceases to flow. Then the injection should be made. If the needle lies in the sacral canal there is practically no resistance to the flow of fluid from the syringe. If it lies superficial to the sacrum there is usually a considerable amount of resistance to the flow and one sees immediately a subcutaneous tumor form at the site of injection. The whole operation can be rendered practically painless by preliminary infiltration of the skin and subcutaneous tissue over the hiatus with a solution of 0.25 per cent. novocaine.

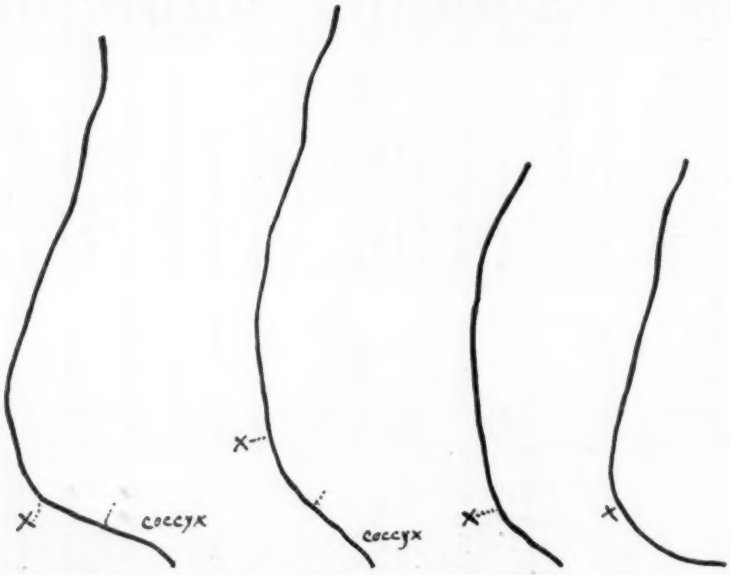
For the purpose of making the study more complete we have made a careful examination of the available "sacra" in the dissecting room of the University of Texas. In all thirty-three specimens were examined. The bones had been macerated and cleaned thoroughly so that no fibrous or membranous material had been left attached to the cornua of the hiatus sacralis. A strong straight steel knitting needle was used as a probe so as to preclude any possibility of bending and to imitate as closely as possible the behavior of the needle used for making injections. The probe was passed through the hiatus upward along the sacral canal, and if arrested the locality was compared with that of the sacral foramina and so noted down in the table. The following table gives an analysis of the anatomical features noticed.

Number of museum specimen.	Distance in cm. that a probe can be passed upward along the sacral canal from the hiatus sacralis.	Upper level reached by the probe.	Type of sacrum.	Shape of the hiatus sacralis.	Level of upper end of hiatus sacralis.	Distance between upper end of hiatus sacralis and lower ends of the cornua.
1	4.5 cm.	2d sacral foramen	Very curved	Horseshoe shaped; short flattened	4th sacral foramen	1.5 cm.
2	6.0 cm.	1st sacral foramen	Slightly curved	Horseshoe shaped; very long	Between 3d and 4th sacral foramina	2.5 cm.
3	Whole canal	....	Flat	Long horseshoe	Lower part of 3d sacral foramen	3.5 cm.
4	5.0 cm.	2d sacral foramen	Quite curved	Short horseshoe; fused with coccyx	Lower part of 4th sacral foramen	1.0 cm.
5	Whole canal	....	Flat	Short horseshoe; fused with coccyx	Upper part of 4th sacral foramen	1.4 cm.; coccyx fused.
6	" "	....	"	Long horseshoe; broad	Lower part of 3d sacral foramen	3.0 cm.
7	" "	....	"	Short horseshoe	Lower part of 4th sacral foramen	1.9 cm.
8	" "	....	"	Broad horseshoe; fused with coccyx	Lower part of 4th sacral foramen	1.9 cm.
9	" "	....	"	Broad, short horseshoe	Lower part of 4th sacral foramen	1.0 cm.
10	6.0 cm.	Upper part of 2d sacral foramen	"	A shallow curve fused with coccyx	Upper part of 5th sacral foramen	Almost same level as apex; coccyx fused.
11	4.9 cm.	Between 1st and 2d sacral foramina	Slightly curved	Very long horseshoe	3d sacral foramen	2.7 cm.
12	Whole canal	....	" "	Very long and broad horseshoe	3d sacral foramen	3.5 cm.
13	5.8 cm.	Lower part of 1st sacral foramen	Curved	Horseshoe; very symmetrical	4th sacral foramen	1.7 cm.; cornua very prominent.
14	Whole canal	....	Flat	Sharply triangular	3d sacral foramen	2.6 cm.; cornua very prominent.
15	" "	....	"	Triangular; blunt at the apex	Between 3d and 4th sacral foramina	2.5 cm.; cornua very prominent.
16	2.5 cm.	Upper part of 4th sacral foramen	Very curved	Horseshoe	Between 4th and 5th sacral foramina	2.0 cm.; first coccygeal fused with sacrum.

17	Whole canal	....	Flat	"	Lower end of 3d sacral foramen	3.5 cm.
18	" "	....	Very flat; curved at lower end	Equilateral triangle	Between 3d and 4th sacral foramina	2.3 cm.
19	" "	....	Flat	High isosceles triangle	Between 3d and 4th sacral foramina	3.0 cm.; cornua overhang 5th foramen.
20	" "	....	Quite curved	Long horseshoe	Lower part of 3d sacral foramen	5.0 cm.; whole coccyx fused.
21	" "	....	" "	An isosceles triangle	Between 3d and 4th sacral foramina	4.5 cm.; cornua fused with coccyx.
22	" "	....	Flat	Short horseshoe	Upper part of 4th sacral foramen	1.0 cm.; fused coccyx.
23	" "	....	Very curved	An isosceles triangle	Between 3d and 4th sacral foramina	3.3 cm.
24	" "	....	Flat	Very irregular	4th sacral foramen	1.0 cm.
25	5.5 cm.	Lower part of 1st sacral foramen	Curved	Horseshoe with contracted ends	Between 3d and 4th sacral foramina	2.0 cm.
26	Whole canal	....	Flat, curved sharply at lower end	An irregular horseshoe	Between 3d and 4th sacral foramina	2.5 cm.; anterior and posterior walls of canal almost in contact.
27	" "	....	Flat	Horseshoe	Lower part of 4th sacral foramen	2.5 cm.; fused coccyx.
28	5.8 cm.	Lower part of 1st sacral foramen	Fairly curved	Small horseshoe	4th sacral foramen (compare No. 22)	1.5 cm.
29	Whole canal	....	Very flat	Obtuse angled triangle	Between 4th and 5th sacral foramina	2.0 cm.
30	" "	....	Fairly curved	Very long triangle	Between 2d and 3d sacral foramina	4.0 cm.
31	" "	....	Flat	Horseshoe shaped	4th sacral foramen	2.0 cm.
32	" "	....	Very flat	Staple shape	Between 4th and 5th sacral foramina	1.0 cm.; canal very capacious.
33	" "	....	Flat	Horseshoe shaped	Lower part of 5th sacral foramen	2.5 cm.; fused coccyx.

In 24 out of the 33 specimens examined the probe passed along the whole canal. In the remaining 9 it passed in all except 1 (No. 16) as high or higher than the second sacral foramen. In this specimen it passed along the canal for a distance of 2.5 cm. and reached as high as the upper part of the fourth sacral foramen. The sacrum was very curved, especially at its lower end, and the level of the apex of the hiatus was just below the bend of the curve, between the fourth and fifth sacral foramina. The first coccygeal vertebra was also fused. The specimen is figured in one of the photographs, and a tracing of the curve is also shown in one of the figures.

In only one case was the canal so narrow as to raise doubts whether a needle could be passed along it. In specimen No. 26 the anterior and pos-



No. 16.— Curved type of sacrum, fused coccyx; opening of hiatus shown by a cross.

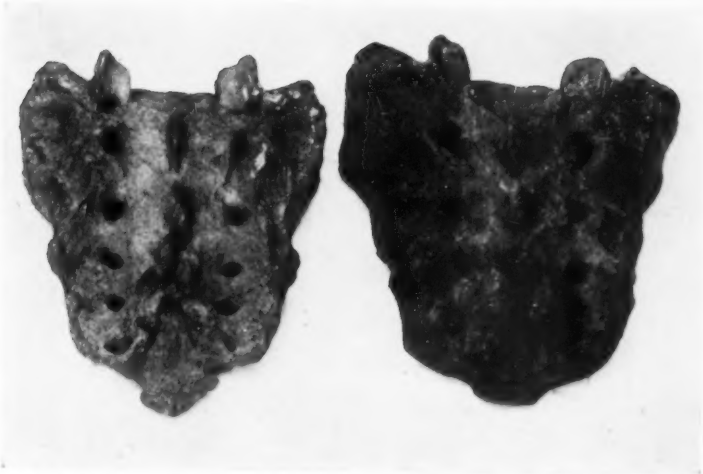
No. 20.—Long, flattened type of sacrum; fused coccyx; opening of hiatus shown by a cross.

No. 9.— Short, flattened type of sacrum; opening of hiatus shown by a cross.

No. 1.— Curved type of sacrum; opening of hiatus shown by a cross.

terior walls were so close together as to reduce the canal to a mere slit, which, however, admitted the knitting needle. In every case of the series the sacral canal was accessible to the needle. Even in No. 16, although the needle did not pass higher than the fourth sacral foramen, it entered the canal high enough to allow the needle to pass into the loose cellular space in which the sacral nerves lie. There seems no reason to doubt that if the needle penetrates the fibrous membrane that closes the hiatus and enters this loose cellular space, the injected fluid will pass upward around the nerves and around the dura mater.

PLATE A.



No. 5.—Sacrum moderately long. First coccygeal vertebra fused with sacrum. Hiatus fairly large, shaped like a horseshoe. Apex of hiatus bounded by an irregular mass of bone corresponding to the spinous processes of the third and fourth sacral vertebræ. Fifth foramen complete in front and behind on left side; complete in front only on the right side.

No. 15.—Hiatus large, triangular in shape, blunt at the apex. Margins of hiatus irregular and knobby. Formed by ununited spines of the fourth and fifth sacral vertebræ.

No. 29.—Sacrum rather long. Opening of hiatus shaped like a small obtuse-angled triangle. Margin of hiatus surrounded by massive knobs of bone. Apex of hiatus formed by united spinous processes of fourth sacral.

No. 18.—Sacral very short. Margins of hiatus very prominent. Opening of hiatus shaped like an equilateral triangle. The fourth sacral spines have not united.

PLATE B.

No. 12.—Hiatus very long and shaped like a horseshoe. The upper end is at the level of the third sacral foramen. The margins of the hiatus are formed by two flattened ridges in which can be seen rudiments of the spinous processes of the fourth and fifth sacral vertebræ.

No. 30.—Hiatus very long and shaped like an isosceles triangle. The upper end reaches to the upper margin of the third sacral foramen. The margins are flattened and are formed by the fused spinous processes of the fourth and fifth sacral vertebræ.

PLATE C.

No. 16.—Showing first coccygeal vertebra fused with sacrum. Upper end of hiatus low down between the fourth and fifth sacral foramina. Hiatus well formed. Margins of hiatus formed by the fused spinous processes of the fifth sacral and first coccygeal vertebræ. The fifth foramen complete posteriorly and anteriorly.

No. 10.—Fusion of first coccygeal vertebra with sacrum. The fifth foramen complete in front; represented by a fissure behind. Hiatus represented by a transverse slit at the level of the fifth sacral foramen.

No. 27.—Fusion of first coccygeal vertebra with the sacrum. The fifth foramen complete in front; represented by a fissure behind. Hiatus extends upwards almost to the level of the fourth sacral foramen. Margins are formed by the fused spines of the fifth sacral and the cornu of the coccygeal.

The appended tracings show the curved and flattened types of sacra. (The numbers refer to the table.) No. 1 is a tracing of the anterior surface of a markedly curved sacrum. The coccyx was not fused. The cross shows the position of the upper angle of the hiatus. A probe passed as high as the second sacral foramen. No. 16 is also a type of curved sacrum. In this specimen the opening into the hiatus (marked by a cross) was just below the curve and a probe could not be passed higher than the fourth sacral foramen. No. 9 shows a short, flattened type of sacrum. The opening of the hiatus is shown by a cross. The probe passed along the whole canal. No. 20 shows a long, flattened type with a fused coccyx. The opening of the hiatus is shown by a cross. The needle could be passed along the whole canal.

The sacra showed such variety that it was almost bewildering to attempt to divide them into types. I have appended three plates which bring into contrast certain peculiar features that deserve consideration. (The numbers refer to the table.) In Plate A four sacra of different lengths are contrasted to show the different position and shape of the hiatus and its margins. In Plate B a type with a very large horseshoe hiatus is shown. The contrast between either of these specimens and that of No. 29 in Plate A is striking. In Plate C the type with fused first coccygeal vertebra is shown. The contrast between the shape of the hiatus in No. 10 and that in No. 16 and 27 should be noticed.

TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting, held October 10, 1917

The President, WILLIAM A. DOWNES, M.D., in the Chair

FISTULA FOLLOWING NEPHRECTOMY FOR TUBERCULOSIS

DR. WALTON MARTIN presented a boy seventeen years old, who was admitted to St. Luke's Hospital in February, 1916. He had been suffering for about eight months, his chief complaints being frequency of micturition and dysuria. He had lost weight and for a month before admission had complained of pain in the right side. He was poorly nourished and looked very ill. On cystoscopic examination the orifice of the right ureter was dilated and surrounded by an area of œdema and congestion. The urine from the right kidney was pale and cloudy; the urine from the left kidney was normal. A diagnosis of tuberculosis of the right kidney was made and three weeks after admission the right kidney and the much thickened and rigid upper third of the right ureter were removed. The kidney showed on examination numerous cheesy areas and tubercles, and microscopical examination showed typical tuberculous tissue. The patient recovered satisfactorily from the operation and left the hospital in the third week with the nephrectomy wound healed, except for a small sinus. The sinus did not close and soon began to discharge urine mixed with pus. The boy was kept in the open air and every effort was made to improve his general health, but the sinus continued to discharge, a considerable portion of urine passing out of the sinus each day. Eight months after his operation he was again admitted to the hospital for the discharging urinary sinus. Cystoscopic examination at that time showed a normal bladder and left ureteral orifice. The right ureteral orifice was rigid and patent. After some deliberation it was decided not to operate, but to temporize still further with the hope that the sinus would eventually close. The patient was kept under observation and the sinus irrigated. About five months ago the sinus closed and the boy began putting on weight and is now in excellent health.

Dr. Martin said he had shown the patient on account of the discussions as to the proper disposition of the ureter in cases of tuberculosis of the kidney with involvement of the ureter; second, on account of the urine which discharged from the sinus; the urine secreted by the left kidney passed into the bladder and then backed up into the stump of the rigid, diseased and patent right ureter and so out through the nephrectomy wound; and finally to show the satisfactory outcome and the spontaneous closure of the

sinus. At the time of the operation the boy was seriously ill and it seemed unwise to prolong the operation sufficiently for the removal of the entire ureter.

Dr. Willy Meyer said that about fifteen years ago he presented a similar patient, before this Society; he was a man in whom he had ligated the pedicle of a tuberculous kidney with its vessels and ureter en masse, because it seemed unwise to separate them on account of the inflammation. Everything went well until after awhile a sinus developed and the patient said that fluid was discharged whenever he lay down. Observation showed that in standing he remained quite dry, but when he lay down urine flowed from the sinus. I found the cystoscope showed a much ulcerated mouth of the diseased ureter. This had become insufficient, so that in bed the bladder urine simply ran up to and out at the loin. Dr. Meyer finally reopened the wound and tied the ureter further down, putting the point of the cautery into the lumen and then tying it. This cured the condition.

He coincided with Dr. Martin's views on the inadvisability in weak patients of going further down and removing the whole ureter in these tuberculous cases. He had often divided the ureter as far down as possible and then injected a few drops of pure carbolic. Usually such ureters then take care of themselves. He personally did not recall a single case in which with the tuberculous ureter not completely removed, a persistent, suppurating fistula had followed.

Dr. Alexis Moschcowitz said that he had seen the development of fistulæ in some cases that had been considered exceptionally good cases. He mentioned three cases of tuberculosis of the kidney, among others operated in the past two years. One of them was a very far advanced case. In this case he extirpated most of the ureter. The stump that was left was undoubtedly tuberculous, but much to his surprise the wound healed very promptly. In the second case the diagnosis was made only by finding the tubercle bacillus in the catheterized ureteral specimen of urine. The kidney was not at all enlarged. The nephrectomy was very easy. Several inches of the ureter were extirpated. He sewed up this wound without drainage and it healed in a week or ten days; the patient was discharged in a short time, but returned in three weeks with a tubercular wound! The third case was a counterpart of the last. The kidney and ureter were extirpated. There was no leakage during the operation, but the patient returned in a short time with the wound distinctly tuberculous.

LATE RESULT AFTER THORACOPLASTY FOR CHRONIC EMPYEMA

Dr. Walton Martin presented a boy fifteen years old who was admitted to St. Luke's Hospital four years ago for a persistent thoracic sinus following an operation for empyema two years previously.

There was a sinus in the posterior axillary line in the neighborhood of the sixth rib on the left side. From this sinus large amounts of pus escaped. Every evening there was a rise of temperature; he looked sick and miserable

and there was a marked lateral spinal curvature. A Schede thoracoplasty was performed; the greatly thickened pleura and chest wall over the large intrapleural cavity were removed. As a result the spinal curvature has become corrected, the boy is straight and vigorous with well developed muscles, notwithstanding the deformity of the left chest.

DIVERTICULITIS OF SIGMOID WITH ABSCESS

Dr. Wm. A. Downes presented a man, aged forty-eight years, who for five years had complained of discomfort after meals. Two years ago suffered from an acute abdominal attack accompanied with vomiting and fever. Condition was diagnosed as appendicitis. No operation. Gradually lost weight, and in June, 1917, suffered from a second attack of abdominal pain with vomiting and temperature. This time the pain radiated from the appendix region to the lower abdomen. Urination became frequent and painful. This attack subsided in about ten days. Early in July an X-ray examination by Dr. Schultz demonstrated a definite diverticulitis of the sigmoid. On August 1 marked tenderness was found in the region of the appendix and in the suprapubic region, also tenderness in region of gall-bladder. At operation the gall-bladder was found thickened and contained one large stone and a number of small ones. The appendix was the seat of an old inflammation and bound down by dense adhesions. The gall-bladder and appendix were removed. Exploration of the pelvic region showed a mass, just at the brim of the pelvis to the left of the median line, size of a child's fist. A left lower rectus incision was then made to expose this mass, which was found to involve the sigmoid and fundus of the bladder. In attempting to separate the bladder from the gut an abscess containing about one ounce of pus was opened. The bladder was separated with difficulty, and the sigmoid released. Two or three appendices epiploicæ were removed, but no opening found entering the lumen of the sigmoid. A large rubber-dam drain was inserted in the cul-de-sac through the lower wound angle and the wound closed. An uninterrupted convalescence followed, except that a small secondary abscess opened at the end of four weeks, but closed in a few days.

The patient is now gaining rapidly in weight, and is free from all pain, bowels move regularly. He suffers only an occasional twinge in the region of bladder in voiding.

Dr. John F. Erdmann exhibited a specimen removed from a patient three weeks ago, which had been removed under a diagnosis of carcinoma of the recto-sigmoidal juncture of the colon. In cutting into the hard mass they found a condition of multiple diverticulitis. There are fifty diverticula in a segment of gut 4½ inches by 5 inches long. Further examination has revealed a malignant portion of the bowel associated with one of the diverticula. This is the third case he had had in which malignancy has arisen from an apparently ulcerated diverticulum.

Dr. William B. Coley said that these cases of diverticulitis are difficult to diagnosticate. In the case of a woman who was operated four and

a half years ago for a condition supposed to be acute appendicitis, what was supposed to be a colitis had developed, for which a nurse had been giving enemas. After one of these enemas she developed a temperature of 102° and a good deal of abdominal pain; she was tender over the lower abdomen. He could make out an indefinite mass over the lower abdomen a little more to the left than to the right, which seemed to be a malignant obstruction of the sigmoid. When the abdomen was opened they found a mass in the sigmoid so tightly adherent to the tube and ovary that it was impossible to enucleate and remove it and the attempt was given up. She had a small fecal fistula for a few months, but has been in perfect health ever since, and this operation was performed four and a half years ago.

INGUINAL HERNIA IN THE MALE

Dr. Seward Erdman presented a paper with the above title, for which see page 702.

INGUINAL HERNIA: CASES PRESENTING SPECIAL FEATURES

Dr. Irving S. Haynes presented a boy, fourteen years of age, who was operated upon January 25, 1910, for the cure of a right congenital oblique inguinal hernia by the Bassini technic. The appendix was removed through the same incision. Hemorrhage from the superficial epigastric on the third day. This was controlled by an additional suture. Uncomplicated recovery. Patient left the hospital on the eighth day.

Case II.—Adult male, operated May 30, 1917, for relief of a small hernia in the left inguinal region present for three years. Has worn truss. For past two weeks has had attacks of intestinal cramps, one very severe. The pain was very severe, with general abdominal tenderness, more marked in left iliac region; but there was nothing to be felt in the inguinal region. Operated. The inguinal canal was filled with a mass of properitoneal fat three or four inches long. There was practically no conjoint tendon, there being a free space from the edge of the rectus to beyond the middle of Poupart's ligament. Fat excised, no hernial sac found, inguinal canal repaired by Bassini method. So far no explanation for intestinal symptoms. Abdomen opened at left of midline, nothing found except an appendix, deeply placed near the middle of the abdomen, hard and injected and covered by adhesions. It was removed. Wound closed. Symptoms have not returned. Dr. Haynes called attention to the condition prevalent in fat people, of more or less fat in the inguinal canal and a serious defect in the posterior wall of the inguinal canal. Also to an inflamed appendix causing symptoms of intestinal disturbance, in this case attributed to the hernia.

Case III.—E. S., male, operated sixteen years previously for a strangulated hernia on the left side. Recurrence began four years ago; now hernial mass, 6 by 4 inches. Operated, October 14, 1914. Mass of omentum as large as two hands excised. Inguinal region reconstructed by usual technic.

CASE IV.—R. S., male, operated February 4, 1916, for double inguinal hernia, reducible, and of the oblique variety. Bassini method followed.

CASE V.—E. R., male, operated on June 15, 1915, for indirect inguinal hernia on the right side. The external ring was one inch in diameter. There was also a weak scar following an operation for appendicitis performed nine years previously. Elliptical incisions removed the old scar and opened up the inguinal region. The appendix region was dissected free and the muscles united in layers. A large mass of omentum adherent to the hernial sac was removed with the sac and the repair made after Bassini.

CASE VI.—A., male, aged thirty-seven, operated September 7 last. There was a congenital hernia on the right side and a weakness on the left. The appendix was removed through the right hernial incision. It was retrocæcal and peritoneal. In its removal it was punctured by the teeth of an Ochsner's clamp. Precautions were taken and the wound sutured tight. At the end of the first week a small mural abscess had to be drained. Both sides were repaired by the Bassini technic.

CASE VII.—H. B., male, operated September 25 last. He had a congenital inguinal hernia on the right side with an open funicular process of large size from the abdomen to the testicle. This hernia was dealt with in the usual manner. On the left side there was an undescended testicle. After exposing the inguinal region there was a small mass protruding through the external ring. The canal was opened and the testicle, of good size, occupied the centre. There was a large peritoneal pouch, funicular process, from the abdomen to the testicle. Testicle freed, funicular process divided across, the abdominal gap closed by suture, and the testicular portion sutured to form a tunica vaginalis. The vas and vessels were freed; they were found of sufficient length to permit the testicle to be readily placed in the scrotum, because they were looped downward through the external ring and then returned to the testicle. Some redundant tissue was excised. The canal was reconstructed and the external ring made rather tight. An artery forceps was tunnelled to the bottom of the scrotum and the latter grasped and brought up into the wound. A suture of kangaroo tendon was passed through the scrotal and testicular tissues and tied. The testicle then placed in the scrotum and the incision closed without drainage. Recovery was attended with little reaction. There was quite some ecchymosis in the scrotal tissues. It is now fifteen days since the operation.

CASE VIII.—M., male, aged twenty-four. Had double indirect inguinal hernia of one and a half years standing. The right larger than the left. On September 10 last, operations were performed on both sides following the Bassini technic. At the same time the appendix was removed through the right incision. He left the hospital at the end of ten days.

CASE IX.—J. C. Had a right, indirect inguinal hernia. A Bassini operation was done on September 5 last. The appendix was removed through the same incision. Patient left the hospital at the end of eleven days.

Dr. Haynes, in regard to the prevention of recurrences, called attention to a condition prevalent in fleshy people. It is the absence of the posterior wall of the inguinal canal. This results when the loop of the internal oblique and transversalis muscles swings from the middle of Poupart's ligament to a narrow conjoint tendon, leaving a broad gap in the posterior wall, and there is nothing to resist bulging at this point except the fascia of the external oblique. This anatomical defect is one of the most essential factors to correct when repairing this region. Then again, in fleshy people there is so much adipose tissue mixed with the muscle fibres and also such thin fascia that overlapping methods, especially in the external oblique, are necessary to reconstruct a really strong layer of the inguinal canal.

Another point in the prevention of relapses is to form an internal ring external to the middle of Poupart's ligament by suturing the internal oblique and transversalis muscles to the inguinal ligament behind the cord.

Dr. Alexis Moschcowitz said that the fact, notwithstanding the high character of the work done at the New York Hospital, they had had at least 6.86 per cent. recurrences, bears out what he had frequently stated, namely, that one cannot go by textbooks or by published reports regarding the number of recurrences. He was of the opinion that if one could obtain statistics of every hernia operation done, not only of that of the operator who operates a large number of hernias, but also that of the operator who operates only occasionally, the number of recurrences would be considerably higher than is usually stated. Another important point not to be overlooked is that one is in reality dealing with two different herniæ, although they are classed together under the generic name inguinal hernia. Oblique inguinal hernia is, so far as the ultimate cure is concerned, totally different from direct inguinal hernia. The oblique are easily curable, but the direct are very difficult to cure. It makes all the difference in the world what operation is done whether one is dealing with an oblique or a direct inguinal hernia.

He could not agree absolutely with Dr. Haynes when he lays so much emphasis upon the fat content of the muscles; it does make some difference, but not of such tremendous importance. Some years ago he did 25 or 30 cases hand running with one recurrence, in which he absolutely neglected to avail himself of the muscle. In other words, he paid no attention to the internal oblique or to the transversalis. After splitting the aponeurosis of the external oblique he transplanted the upper leaf of the external oblique to Poupart's ligament; on top of that he sutured the lower leaf of the aponeurosis of the external oblique. However, now he salves his conscience by suturing the aponeurosis of the external oblique, the internal oblique and transversalis muscle to Poupart's ligament and on top of that he sutures the lower leaf of the aponeurosis of the external oblique.

Dr. William B. Coley said that surgeons do not pay enough attention to these sequelæ to inguinal hernia. A year ago a very important exposition was made by Lincoln Davis of fifteen hundred cases operated on in the

Massachusetts General Hospital in ten and a half years, in which he laid particular stress on the sequelæ. It is interesting to note that the larger number of sequelæ occurred among the fifty-three operators who have performed the smaller number of herniotomies. The greater the experience the fewer the sequelæ. In 438 cases there were sequelæ worthy of note: 158 cases showed sepsis of some form, 98 cases were slight; in the remaining 65 there was frank suppuration. In 170 cases there were pulmonary or respiratory sequelæ, pneumonia in seven cases and bronchitis in the others. The rarer sequelæ were otitis media, cholangeitis, one case; mental trouble in three cases; neuritis in three cases. No mention was made of hydrocele. There were six per cent. of recurrences noticed. At the Hospital of the Ruptured and Crippled up to January, 1917, in 5617 operations of the inguinal canal, there were .6 per cent. recurrences. In their earlier cases there were a certain number of cases followed by suppuration and they lost one or two cases from sepsis, but in the last ten or fifteen years these cases have been remarkably few and there has been no fatality from sepsis for a great many years. The cases of hydrocele in children are remarkably few. He had seen a number in adults, mostly many years ago. They are usually due to too little care in separating the sac, in handling the tissues of the cord, and particularly in not removing the sac down to the testicle proper. The hydrocele is due to too much manipulation of the cord, making the canal through the upper ring too tight, and causing congestion of the cord vessels.

He had had two or three cases of phlebitis. There is another complication which they used to see in the New York Hospital in the early nineties. There were three cases reported by Dr. Bull of omental tumors following hernia operations. These were inflammatory masses due to ligation of irreducible omental herniæ in one large ligature. In such cases within two or three days or a week a mass could be felt in the abdomen as high as the umbilicus, increasing to the size of a child's head. The temperature sometimes went as high as 103°. One case went on to abscess and death. When they began to tie off the omentum in small masses that complication ceased.

Another complication at the Hospital for the Ruptured and Crippled is caused by the use of non-absorbable ligatures. The patient returns for treatment in from one month to three years with a sinus. A large number of cases was reported by Dr. Bull and himself with a plea for the use of absorbable sutures. In Europe they still use some form of non-absorbable sutures in many clinics. Only a year ago he had under his observation a young man operated on in England in order to join the army, which he was assured he could do within six weeks of his operation. However, his wound did not heal well and he was told to take a vacation as a little sinus had formed, so he came to America and took a position as butler. Dr. Coley found several buried silk sutures with a sinus from his hernia operation and one or two sutures where he had a varicocele operated upon. After a long period his sinus finally healed. Not long ago he had two cases, both operated on in

Europe, where silk was used, and sinuses persisted until these sutures were removed by operation. Kangaroo tendon or chromic catgut fulfils all the ideals of a proper suture and ensures permanent results without these unfortunate secondary recurrences.

One word about the technic as to transplanting the cord. Surgeons should not have an invariable rule to transplant or not to transplant. As a rule he never transplanted in a case associated with undescended testis. They treated 700 cases in which they did not transplant the cord, cases similar to those in which they did, and the results in children showed improvement where they did transplant and in adults the results were even better.

Dr. William C. Lusk said that little was ever said of the importance of the transversalis fascia in the repair of inguinal hernia. Transversalis fascia normally occupied the whole floor of the inguinal canal and in indirect inguinal hernia the opening in this fascia through which the hernia came was perhaps the only part of the inguinal canal that actually needed repair and reinforcement. In order to guard against recurrence at the internal ring in these herniæ, Dr. Halsted had laid down the principle that the transversalis fascia should be dissected away from the sac at the internal ring so that, in tying off the sac, only peritoneum would be included in the ligature and the stump could then retire behind the abdominal wall. Should, however, the transversalis fascia overlying the neck of the sac be left *in situ* and be included within the grasp of the ligature that tied off the sac, it could be seen that by thus leaving the stump of the sac to protrude through the internal abdominal ring, a source of weakness would be introduced at the very situation where a careful reconstruction of the layers of tissue was needed. When, in operating for these herniæ, the neck of the sac had been tied off independently of its fascial connections and its stump had receded well within the internal ring, then it was that by transplantation of the cord with external displacement of the same into the outer angle of the inguinal canal, which manœuvre coincidently drew into an extreme outward position the transversalis fascia attached to the cord, the opening at the internal ring was automatically closed.

Dr. Lusk said that for the repair of direct herniæ he practised Dr. Halsted's operation of taking a flap from the anterior layer of the rectus sheath and sewing it to the inner portion of Poupart's ligament. Dr. Halsted did not transplant the rectus muscle. Dr. Lusk had illustrated the cutting of a rectangular flap from the anterior layer of the rectus sheath for the repair of direct hernia in the Annals of Surgery, November, 1913, p. 677. The anterior layer of the rectus sheath was unyielding; the posterior layer of the rectus sheath contained some slack. By cutting the rectangular flap in the anterior layer of the rectus sheath, the horizontal arm of the flap cutting well out to, but not through, the outer border of the rectus sheath, and the vertical arm cutting downward to the pubic spine, the restraint exercised by this layer of the rectus sheath on the arched fibres of the internal oblique and transversalis muscles was freed and the slack

of the posterior layer of the rectus sheath given play, so that both the arched fibres as well as the rectangular flap could be readily brought down and sutured to Poupart's ligament without tension. The horizontal arm of the rectangular flap should be made about 1¼ inches above the pubic spine.

For protection against recurrences which came as a result of suppuration, Dr. Lusk recommended the use of MacDonald's solution for disinfection of the skin instead of tincture of iodine. The wounds for inguinal herniæ, being through hairy parts, were particularly difficult to disinfect. The tincture of iodine containing no fat-solvent could not reach bacteria embedded in greasy particles, but MacDonald's solution containing the fat-solvent acetone, by liquefying the grease, liberated the bacteria imprisoned therein, thus exposing the latter to the action of the disinfectant ingredient of the solution. The formula was 40 parts acetone, 60 parts alcohol, to which 2 per cent. pyxol was added. His own experience, and the reported results of some others, spoke for the superiority of MacDonald's solution over tincture of iodine for skin disinfection.

Dr. William A. Downes differed with Dr. Erdman in reference to supporting the scrotum. It adds tremendously to the comfort of the patient. In private patients he always uses a suspensory immediately after operation. In direct hernia the recurrences are anywhere from ten to twenty per cent. He had been interested in rectus transplantation for many years, and has transplanted in about 300 cases, but even these have shown from five to ten per cent. of recurrence in those cases which they had been able to follow.

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INDEX TO VOLUME LXVI

H

I

J

K

L

M

W

X

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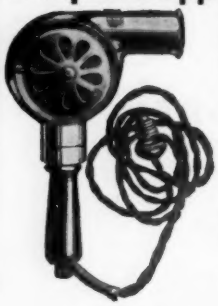

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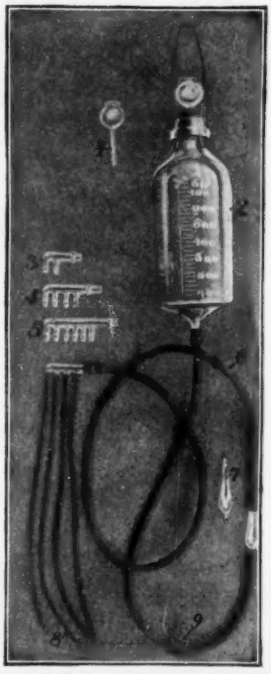

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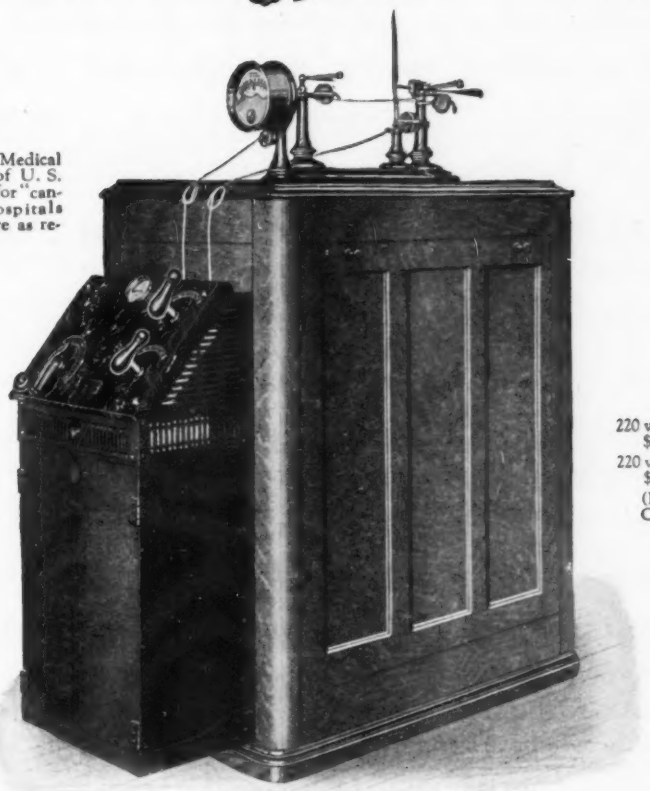

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Assisted by

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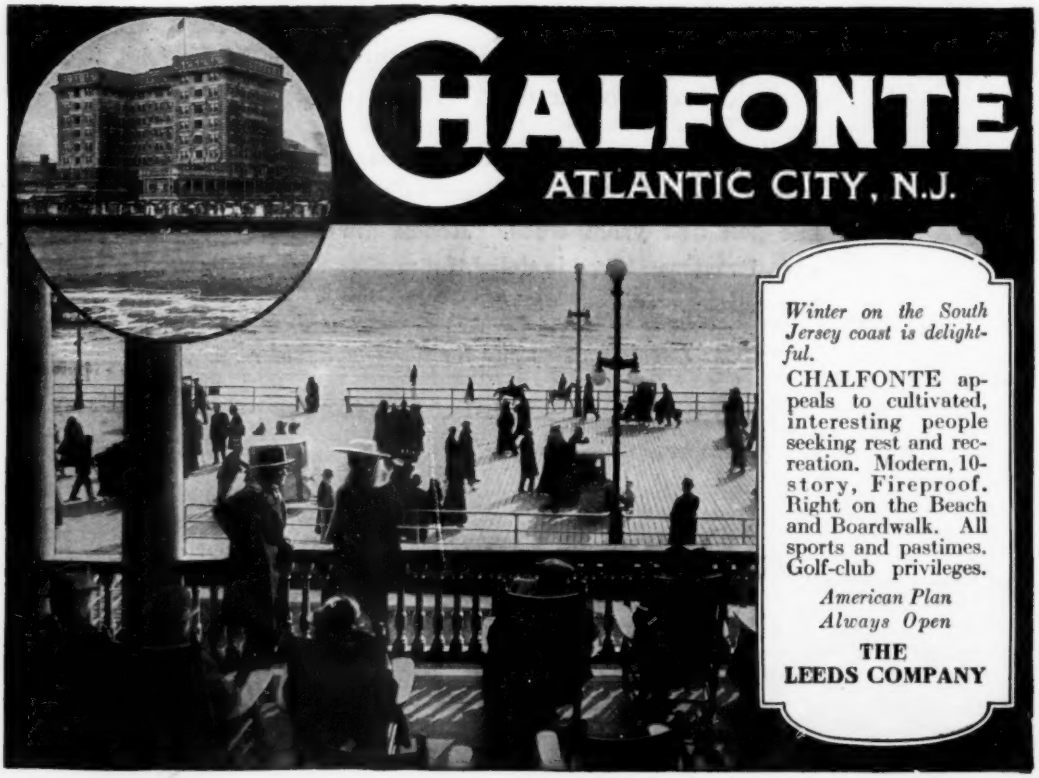

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